# Appendix. Acritarchs and Chitinozoa from the Arenig Series of south-west Wales

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## Synopsis

Thirty-two samples were collected from the Arenig Series of south-west Wales to assess the occurrence and stratigraphical distribution of microfossils. All the samples yielded acritarchs and 6 also yielded chitinozoa. The microfossils are generally poorly preserved and rare, many taxa being represented by single specimens.

The species recorded from 14 samples are grouped into 7 assemblages (Microfossil Assemblages I–VII). Assemblages I–IV are of Moridunian (lower Arenig) age. Assemblage I occurs in the Allt Cystanog Member of the Ogof Hên Formation, assemblages II and III are present in the Cwmffrŵd Member of the Carmarthen Formation, and assemblage IV occurs in the Cwm yr Abbey Member of the same formation and at the base of the overlying Afon Ffinnant Formation. Assemblage V is of Whitlandian (middle Arenig) age, occurring in the Whitland Abbey Member of the Colomendy Formation. Assemblages VI and VII are both of Fennian (upper Arenig) age, and occur in the Pontyfenni Formation.

Biozones are not formally defined, but published and unpublished sources suggest that at least some of the microfossil assemblages from south Wales are comparable with those from Arenig rocks of northern England, north Wales and western Europe.

One new acritarch species *Stellechinatum papulessum* is described and one new combination *Stellechinatum uncinatum* (Downie) is proposed. Several acritarch and one chitinozoan species are described under open nomenclature.

## Introduction

Fortey & Owens (1978, 1987) have demonstrated the presence of a complete and fossiliferous Arenig succession in south-west Wales, extending from east of Carmarthen to Ramsey Island

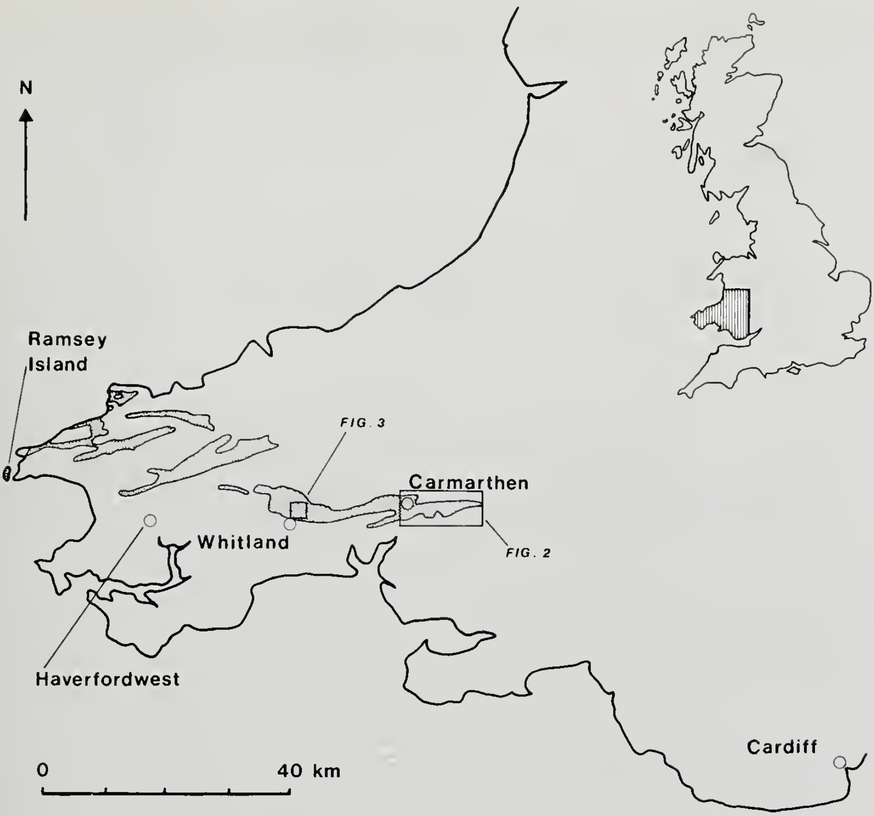



**Fig. 1** Outcrop of Arenig rocks in south-west Wales (stippled).

(Fig. 1). Acritarchs and chitinozoa have been recorded from Arenig rocks in the Carmarthen–Whitland area; in this paper, their stratigraphical distribution is described.

Lower Arenig lithostratigraphy in the Carmarthen area is as follows (Fortey & Owens 1978, 1987):

| | | minimum thickness |
|---|---|---|
| Afon Ffinnant Formation | | ? |
| Carmarthen Formation | Cwm yr Abbey Member | 45 m |
| | Cwmffrŵd Member | *c.* 70 m |
| | Pibwr Member | 85 m |
| Ogof Hên Formation | Bolahaul Member | 50 m |
| | Allt Cystanog Member | 25 m |

The Allt Cystanog Member of the Ogof Hên Formation comprises conglomerates, sandstones and siltstones. Its contact with the underlying Tremadoc rocks is nowhere exposed but it becomes finer upwards, passing through a transition into the micaceous mudstones and shales of the Bolahaul Member. The lowest 5 m of the Pibwr Member, comprising the lowest beds of the Carmarthen Formation, are transitional in character with the Bolahaul Member. Above that, the Pibwr Member comprises black, well-bedded mudstones. Above the Pibwr Member, the Carmarthen Formation is divided into the Cwmffrŵd Member, consisting of turbidites and shales, and the Cwm yr Abbey Member, comprising grey, poorly bedded mudstones. The latter are overlain by turbidites of the Afon Ffinnant Formation.

The Afon Ffinnant Formation is considered to be equivalent to the Blaencediw Formation of the Whitland area, where the middle and upper Arenig sequence is as follows (Fortey & Owens 1987):

| | | minimum thickness |
|---|---|---|
| Llanfallteg Formation (in part) | | 100 m |
| Pontyfenni Formation | | 300 m |
| Cwmfelin Boeth Formation | | 100 m |
| Colomendy Formation | Whitland Abbey Member | 200 m |
| | Castelldraenog Member | *c.* 150 m |
| | Rhyd Henllan Member | *c.* 150 m |
| Blaencediw Formation | | 80 m |

The Blaencediw Formation consists of poorly graded turbidites and channelled mass flow deposits, gritty shales and siltstones, and occasional black shales. Its base is not seen. The Colomendy Formation is divided into the sandy and silty shales of the Rhyd Henllan Member, the grey, fissile shales of the Castelldraenog Member and the black, poorly fissile shales of the Whitland Abbey Member. The latter are overlain by the well graded turbidites and black shales of the Cwmfelin Boeth Formation. The Pontyfenni Formation consists of black or dark grey shales and poorly fissile mudstones, passing upwards into the light grey mudstones and shales of the Llanfallteg Formation. The base of the Llanvirn Series lies within the latter.

Fortey & Owens (1987) define seven trilobite assemblage biozones in the Arenig Series of south-west Wales. The *Merlinia selwynii* Biozone is well developed in the Bolahaul and Pibwr Members. The *Merlinia rhyakos* Biozone occurs in the Cwmffrŵd and Cwm yr Abbey Members and in the lowest 40 m of the Afon Ffinnant Formation. The *Furcalithus radix* Biozone is restricted to the Afon Ffinnant Formation and probably also to the Blaencediw Formation. The base of the succeeding *Gymnostomix gibbsii* Biozone is presumed to lie within the lower half of the Afon Ffinnant Formation and close to the boundary of the Blaencediw and Colomendy Formations. The *Stapeleyella abyfrons* Biozone is represented by faunas from several localities in the basal Pontyfenni Formation but the base of the Biozone is arbitrarily taken at the base of the Cwmfelin Boeth Formation. The upper two-thirds of the Pontyfenni Formation is included in the *Bergamia rushtoni* Biozone and the Arenig part of the Llanfallteg Formation in the *Dionide levigena* Biozone. (See Fig. 4.)

On the basis of the trilobite faunas, three major divisions of the Series have been recognized. The base of the lower Arenig Moridunian Stage, incorporating the *M. selwynii* and *M. rhyakos* Biozones, has still to be defined. The base of the succeeding Whitlandian Stage is placed 40 m above the base of the Afon Ffinnant Formation and coincides with the base of the *F. radix* Biozone. The base of the upper Arenig Fennian Stage is defined at the base of the Cwmfelin Boeth Formation and is arbitrarily correlated with the base of the *S. abyfrons* Biozone. The base of the Llanvirn Series, defining the top of the Fennian, is taken at the first appearance of pendent didymograptids in the type section of the Llanfallteg Formation.

The Arenig rocks of south-west Wales were deposited at the edge of the Gondwanan continent (Fortey & Owens 1984). The Ogof Hên Formation comprises shallow water sediments, deposited during the initial phase of the Arenig transgression and containing the *Neseuretus* Community, an association of inshore trilobites (Fortey & Owens 1978). In the Pibwr Member, this association is replaced by the Raphiophorid Community, suggesting deeper water, which in turn is replaced in the Cwmffrŵd and Cwm yr Abbey Members by the Olenid Community, indicating deep, oxygen-deficient conditions. It is believed that the Carmarthen area was the site of a stagnant basin with restricted oceanic circulation, separated from the open ocean by a positive, fault-bounded block or blocks in the Haverfordwest district. The turbidites of the Afon Ffinnant and Blaencediw Formations mark the end of the restricted Olenid basin, the abundance of dendroid graptolites at certain horizons in the Blaencediw Formation suggesting quiet, shallow, oxygenated conditions. In the later Whitlandian, the trilobite and graptolite faunas provide evidence for an open oceanic environment. This environment persisted into the

Fennian, predominantly a time of mud deposition throughout south Wales with local turbidite sedimentation represented by the Cwmfelin Boeth Formation in the Whitland area. The faunal evidence suggests that the Pontyfenni Formation may have been deposited at a depth of 300 m or more, and the Llanfallteg Formation at shallower depth but probably more than 200 m. There is every indication that sedimentation was continuous throughout the Arenig and across the Arenig–Llanvirn boundary.

## Palynology

Thirty-two samples have yielded acritarchs and six have also yielded chitinozoa. Abundance and diversity are generally low and preservation is poor; much of the material is heavily carbonized, opaque and brittle. Several specimens are distorted by the internal growth of crystals, probably of pyrite.

### Sampling

Full details of sample localities (Figs 2, 3) are given on pp. 359–60.

*Ogof Hên Formation.* Five samples were collected from this formation, one (MPA 20074) from the top of the Allt Cystanog Member and four (MPA 20075–6, 20079–80) from the Bolahaul Member. All yielded microfossils.

*Carmarthen Formation.* Four samples (MPA 20077–8, 20086–7) were collected from the Cwmffrŵd Member and nine (MPA 20081–5, 20088–90, 20103) from the Cwm yr Abbey Member. All yielded acritarchs. No samples were collected from the Pibwr Member.

*Afon Ffinnant Formation.* Two samples (MPA 20104–5) from the base of this formation yielded acritarchs.

*Colomendy Formation.* Five samples (MPA 20094–8), all yielding acritarchs, were collected from the Whitland Abbey Member. No samples were collected from the Rhyd Henllan and Castell-draenog Members nor from the underlying Blaencediw Formation.

*Pontyfenni Formation.* Four samples (MPA 20099–102) were collected immediately above the base and three (MPA 20091–3) from about the middle of this formation. All yielded microfossils.

No samples from the Cwmfelin Boeth or Llanfallteg Formations were examined.

### Biostratigraphy

The definition of acritarch biozones is unjustified because sampling and recording of species is incomplete, but the microfossils can be grouped into seven assemblages (I–VII). The stratigraphical position of these assemblages is shown in Fig. 4 and the occurrence of microfossil taxa in Fig. 5.

*Microfossil Assemblage I.* This is present in MPA 20074 and includes the acritarchs *Acanthodiacrodium* aff. *spinum* Rasul, ?*Coryphidium minutum* Cramer & Diez, *Micrhystridium* aff. *acuminosum* Cramer & Diez, *Polygonium* sp. A, ?*Uncinisphaera*? sp. D, *Veryhachium minutum* Downie, ?*Vogtlandia flosmaris* (Deunff) Dean & Martin and species of *Micrhystridium*, *Peteinosphaeridium* and *Stelliferidium*. One chitinozoan and several scolecodonts were recorded but have not been determined.

*Microfossil Assemblage II.* This occurs in MPA 20077 from the middle of the Cwmffrŵd Member in Nantycaws dingle (Owens & Fortey 1982; Fig. 2C herein) and is dominated by acanthomorphitic acritarchs. Species present include *Acanthodiacrodium* aff. *angustum* (Downie) Combaz, *Baltisphaerosum*? sp., *Cymatiogalea*? sp., ?*Polygonium* sp. A, *Stelliferidium* sp., *Uncinisphaera*? sp. D, *Uncinisphaera*? sp. E and the '*Veryhachium trispinosum*' group. The presence of *Uncinisphaera*? sp. E and '*V. trispinosum*' and the absence of *M.* aff. *acuminosum* distinguishes this assemblage from Microfossil Assemblage I.

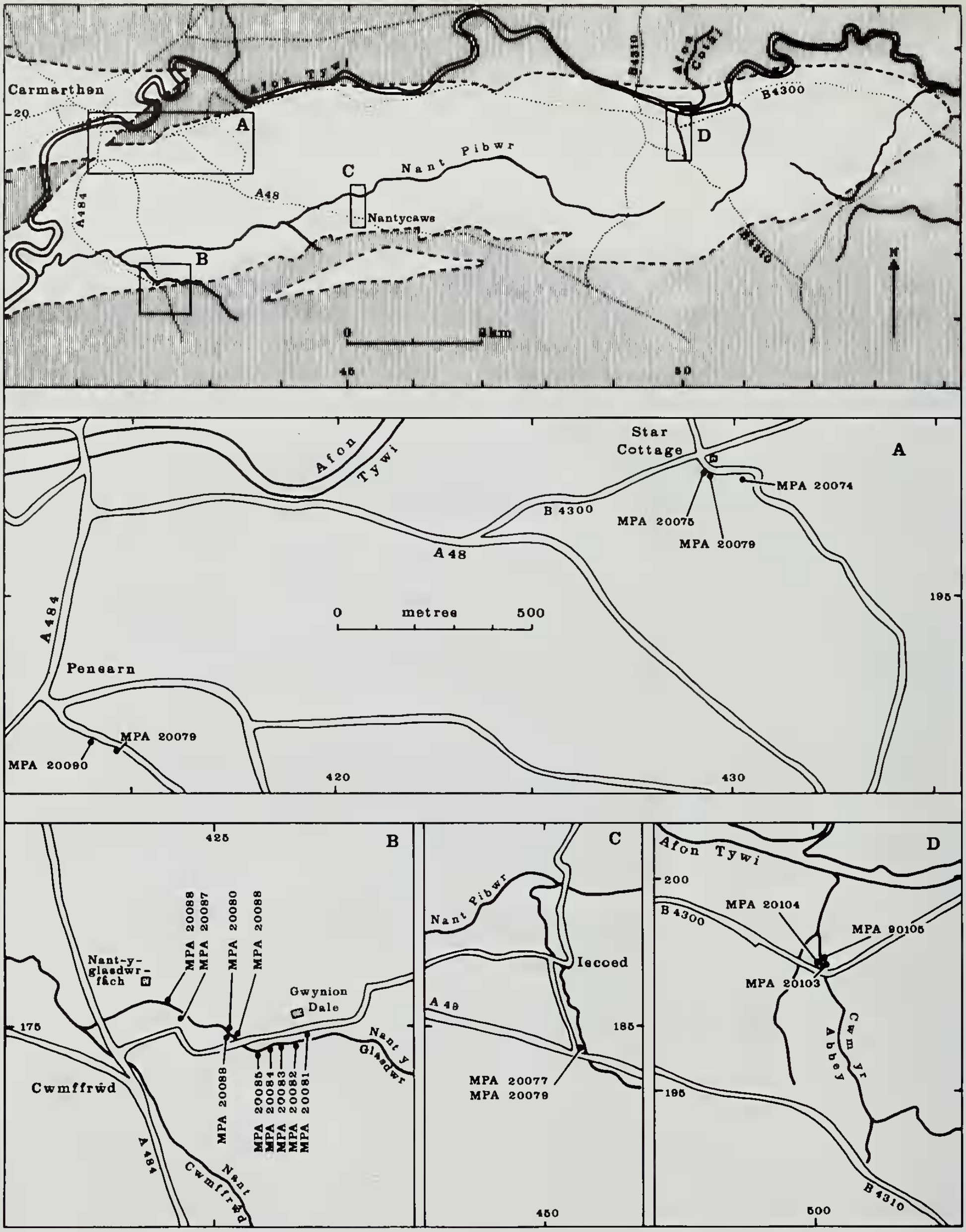



Fig. 2 Sample localities east of Carmarthen. Insets B–D drawn to same scale as A.

*Microfossil Assemblage III*. One sample (MPA 20087) from the top of the Cwmffrŵd Member in Nant y Glasdwr yielded a poor microflora in which a number of acritarch taxa are represented by single specimens. Species present include *Acanthodiacrodium* sp. A, *Barakella* sp. A, *Coryphidium*? sp. A, *Peteinosphaeridium* sp., *Stelliferidium* sp. and cf. *Uncinisphaera*? sp. D.

*Microfossil Assemblage IV*. This occurs in samples from the Cwm yr Abbey Member (MPA 20084, 20103) and the base of the Afon Ffinnant Formation (MPA 20104), comprising a rich

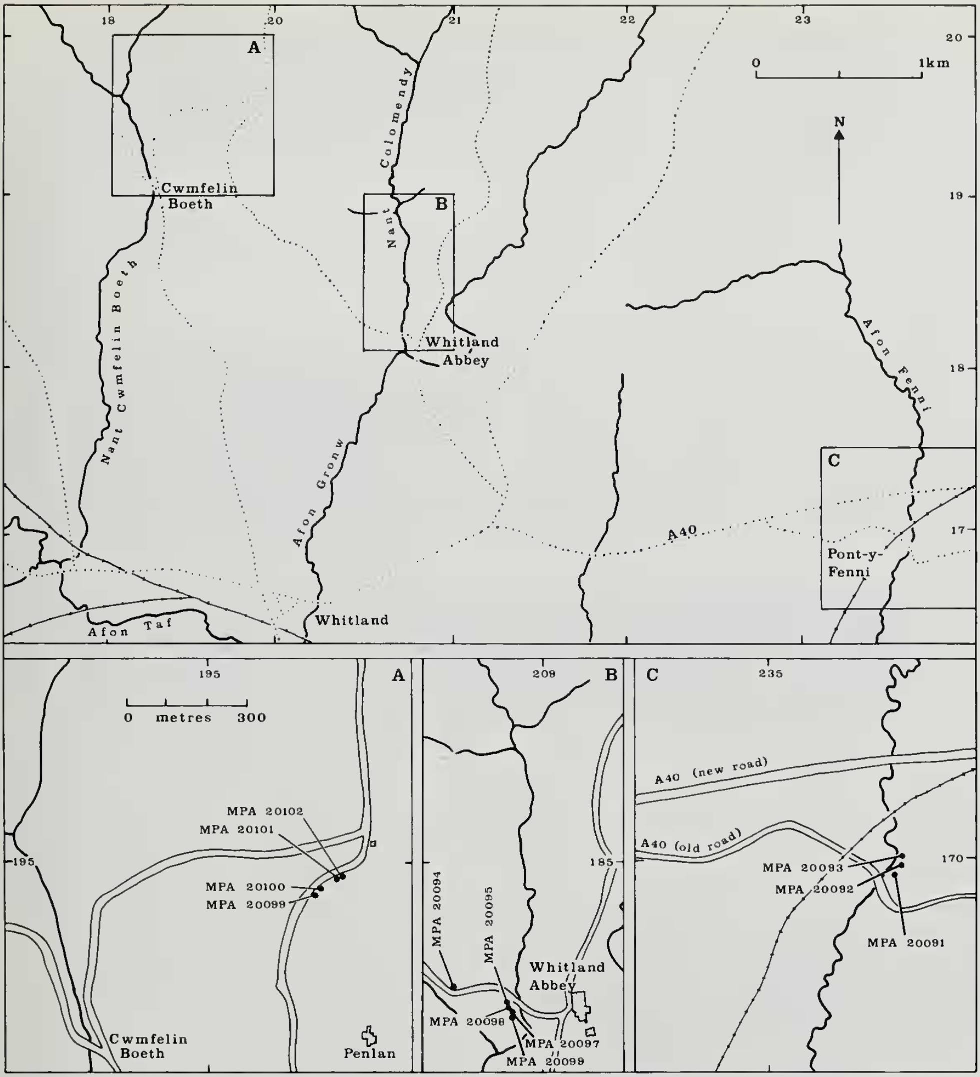



**Fig. 3** Sample localities in the Whitland area. Insets B and C drawn to same scale as A.

and diverse assemblage that is dominated by acanthomorphitic acritarchs. *Micrhystridium* aff. *henryi* Paris & Deunff, *M.* cf. *inconspicuum aremoricanum* Paris & Deunff and *M.* aff. *nannacanthum* Deflandre distinguish this assemblage from others. Other important taxa are *Polygonium* sp. B, *Solisphaeridium* sp. B and *Uncinisphaera*? sp. F.

*Microfossil Assemblage V.* This is present in the Whitland Abbey Member (MPA 20098) and is distinguished by the dominance of small acanthomorphitic acritarchs, including *Micrhystridium* spp. A–D.

*Microfossil Assemblage VI.* This occurs immediately above the base of the Pontyfenni Formation (MPA 20099–102). It comprises a diverse microflora distinguished from other assemblages by the presence of *Coryphidium bohemicum* Vavrdova, ?*Frankea hamata* Burmann, *Orthosphaeridium* sp., *Stellechinatum unicinatum* (Downie) comb. nov., ?*Striatotheca mutua* Burmann,

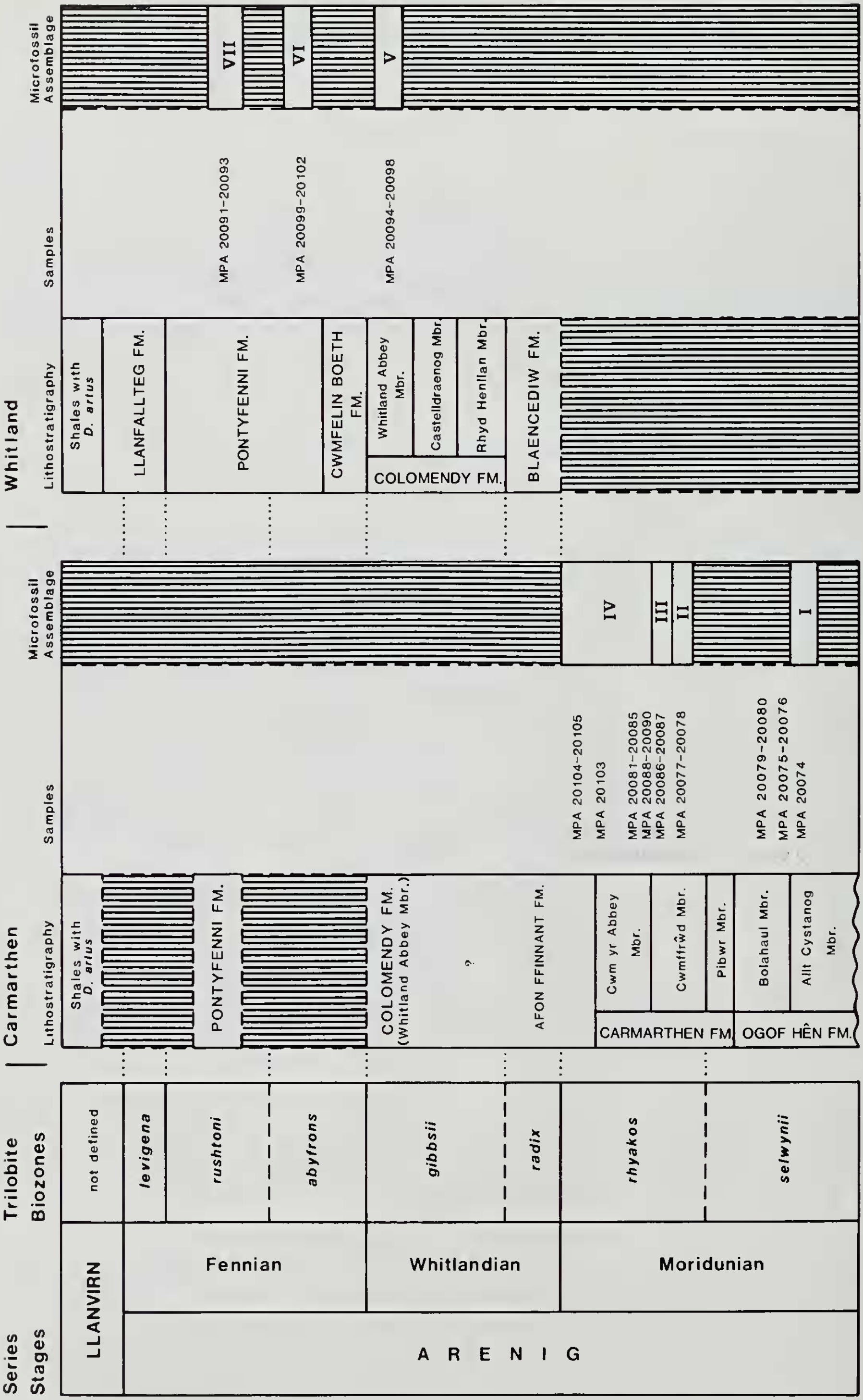



**Fig. 4** The stratigraphical distribution of samples and microfossil assemblages in the Carmarthen and Whitland areas.

?*S. rarirrugulata* (Cramer, Kanes, Diez & Christopher) Eisenack, Cramer & Diez, and *Uncinisphaera*? spp. A and B. Rare chitinozoa and scolecodonts are present in MPA 20099.

*Microfossil Assemblage VII.* Three samples (MPA 20091–3) from the type section of the Pontyfenni Formation yielded diverse and abundant microfossils, including the acritarchs *Coryphidium bohemicum* Vavrdova, *Dasydorus cirritus*? Playford & Martin, *Orthosphaeridium ternatum* (Burmann) Eisenack, Cramer & Diez, *Solisphaeridium* sp. A, *Stellechinatum papulessum* sp. nov, *Stelliferidium* aff. *fimbrium* (Rasul) Rasul and *Uncinisphaera*? sp. C. This assemblage also has a more abundant and diverse chitinozoan fauna than any other, comprising *Belonechitina* spp., *Conochitina* cf. *chydaea* Jenkins, *Lagenochitina* sp. A and *L. cylindrica*? Eisenack.

## Discussion

The samples from the Bolahaul Member yielded rare, small and simple acanthomorphitic acritarchs whose preservation is too poor for identification.

The '*Veryhachium trispinosum*' group may be a useful biostratigraphical marker in the Moridunian. In south-west Wales it appears in Microfossil Assemblage II from the Cwmffrŵd Member of the Carmarthen Formation, and in eastern Newfoundland its earliest recorded occurrence is approximately 500 m above the base of the Arenig (Dean & Martin 1978). However, Martin (1982) showed that it also occurred in the Tremadoc, which suggests that the taxonomy and biostratigraphy of forms placed in the group will have to be revised and clarified before its significance can be appreciated.

Reworked Cambrian and Tremadoc acritarchs, including *Cymatiogalea bellicosa* Deunff, *Timofeevia lancarae* (Cramer & Diez) Vanguestaine, *Vulcanisphaera britannica* Rasul and *V. turbata*? Martin, occur at the top of the Cwm yr Abbey Member in MPA 20103 and immediately above the base of the Pontyfenni Formation in MPA 20099.

## Comparison with assemblages from other areas

Arenig acritarchs are known from other areas of England and Wales, principally through the unpublished work of Booth (1979). Samples collected in north Wales, from the Afon Seiont at Caernarfon, the Menai Straits Inlier and Garth Point at Bangor, are considered to be of Fennian age (Dr R. A. Fortey, personal communication). The acritarch floras contained a number of taxa not recorded from south-west Wales, but also included *Coryphidium bohemicum*, *Striatotheca rarirrugulata*, *Frankea hamata* and *Uncinisphaera*? sp. B, species that are present in Microfossil Assemblage VI. Booth also reported *C. bohemicum*, *S. rarirrugulata*, *Uncinisphaera*? sp., *Orthosphaeridium ternatum* and *Frankea sartbernardensis* (Martin) Burmann from Outerside in the Lake District, where Jackson (1978: 92) recorded graptolites of the *Didymograptus hirundo* Biozone. The Outerside assemblage is again similar to Microfossil Assemblage VI although *O. ternatum* has only been recorded from the higher part of the Pontyfenni Formation, in Microfossil Assemblage VII.

Acritarchs of inferred Arenig age have been described from elsewhere in north-west England. Turner & Wadge (1979) have published an account of 'mid' Arenig acritarchs from the south-western Lake District, recording *C. bohemicum*, *S. rarirrugulata* and *F. hamata*. This assemblage is best compared with Microfossil Assemblage VI and is probably of Fennian age. A similar assemblage was recorded by Molyneux (1979) from the Lady Port Banded 'Group' on the Isle of Man. Lister (*in* Arthurton & Wadge 1981: 6–11) has reported early Ordovician acritarchs from the Cross Fell Inlier where he recognized four assemblages, the older two being of probable late Arenig age. There is little similarity between Lister's assemblages and those from south-west Wales but many key taxa were described subsequent to Lister's investigations in the late 1960s. His material needs to be re-examined before any useful comparisons can be made.

Nothing has been published previously on acritarchs from rocks of known Moridunian or Whitlandian age in Britain, but assemblages from the Glen Dhoo Flags and Lonan Flags on the Isle of Man are of probable latest Tremadoc or earliest Arenig age (Molyneux 1979). Differences between these assemblages and those from the Moridunian of south-west Wales hinder detailed comparison, but the '*Veryhachium trispinosum*' group has not been recorded

| | MPA 20093 | MPA 20092 | MPA 20091 | MPA 20102 | MPA 20101 | MPA 20100 | MPA 20099 | MPA 20098 | MPA 20104 | MPA 20103 | MPA 20084 | MPA 20087 | MPA 20077 | MPA 20074 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Belonechitina* spp. | | | 8 | | | | | | | | | | | |
| *Conochitina* cf. *chydaea* | | | 6 | | | | | | | | | | | |
| *Lagenochitina cylindrica?* | | | 1 | | | | | | | | | | | |
| *Lagenochitina* sp. A | 1 | 11 | 18 | | | | | | | | | | | |
| *?Adorfia prolongata* | 1 | | 1 | | | | | | | | | | | |
| *Dasydorus cirritus?* | 5 | 11 | 2 | | | | | | | | | | | |
| *Orthosphaeridium ternatum* | 1 | | 3 | | | | | | | | | | | |
| *Solisphaeridium* sp. A | | | 4 | | | | | | | | | | | |
| *Stellechinatum papulessum* | 8 | 2 | 3 | | | | | | | | | | | |
| *Stelliferidium* aff. *fimbrium* | | 1 | 1 | | | | | | | | | | | |
| *Uncinisphaera?* sp. C | | | 9 | | | | | | | | | | | |
| *Coryphidium bohemicum* | | 1 | 1 | 4 | | 3 | | | | | | | | |
| *Stellechinatum uncinatum* | 1 | | | | 1 | | 5 | | | | | | | |
| '*Veryhachium trispinosum*' group | 3 | 4 | 16 | | | | 2 | 2 | 3 | 6 | 1 | | 1 | |
| *Cymatiogalea bellicosa* | | | | | | | 1(r) | | | | | | | |
| *?Frankea hamata* | | | | 1 | | | | | | | | | | |
| *Orthosphaeridium* sp. | | | | | 1 | | | | | | | | | |
| *?Striatotheca mutua* | | | | | | | 1 | | | | | | | |
| *?Striatotheca rarirrugulata* | | | | 1 | | | | | | | | | | |
| *Timofeevia lancarae* | | | | | | | 1(r) | | | | | | | |
| *Uncinisphaera?* sp. A | | | | | | | 3 | | | | | | | |
| *Uncinisphaera?* sp. B | | | | | | | 7 | | | | | | | |
| *Vulcanisphaera britannica* | | | | | | | 1(r) | | | | | | | |
| *Vulcanisphaera turbata?* | | | | | | | 1(r) | | | 1(r) | | | | |
| *Nothooidium?* spp. | | | | | 1 | | | | 1 | | | | | |
| *Micrhystridium* sp. A | | | | | | | | 6 | | | | | | |
| *Micrhystridium* sp. B | | | | | | | | 8 | | | | | | |
| *Micrhystridium* sp. C | | | | | | | | 7 | | | | | | |
| *Micrhystridium* sp. D | | | | | | | | 2 | | | | | | |
| *Micrh.* aff. *henryi* | | | | | | | | | 1 | 4 | | | | |
| *Micrh.* cf. *inconspicuum aremoricanum* | | | | | | | | | 3 | 12 | 6 | | | |
| *Micrh.* aff. *nannacanthum* | | | | | | | | | | 2 | 11 | | | |
| *Polygonium* sp. B | | | | | | | | | | | 6 | | | |
| *Solisphaeridium* sp. B | | | | | | | | | | 4 | 2 | | | |
| *Striatotheca* sp. | | | | | | | | | | 1 | | | | |
| *Uncinisphaera?* sp. F | | | | | | | | | | 4 | | | | |
| *Acanthodiacrodium* sp. A | | | | | | | | | | | | 1 | | |
| *Barakella* sp. A | | | | | | | | | | | | 1 | | |
| *Coryphidium?* sp. A | | | | | | | | | | | | 1 | | |
| *Uncinisphaera?* sp. D | | | | | | | | | | | | ? | 7 | ? |
| *Acanthodiacrodium* aff. *angustum* | | | | | | | | | | | | | 1 | |
| *Baltisphaerosum?* sp. | | | | | | | | | | | | | 1 | |
| *Cymatiogalea?* sp. | | | | | | | | | | | | | 3 | |
| *Uncinisphaera?* sp. E | | | | | | | | | | | | | 2 | |
| *Acanthodiacrodium* aff. *spinum* | | | | | | | | | | | | | | 1 |
| *?Coryphidium minutum* | | | | | | | | | | | | | | 1 |
| *Micrh.* aff. *acuminosum* | | | | | | | | | | | | | | 3 |
| *Polygonium* sp. A | | | | | | | | | | | | | | 2 |
| *?Vogtlandia flosmaris* | | | | | | | | | | | | | | 1 |
| Microfossil Assemblages | VII | | | VI | | | | V | IV | | | III | II | I |

**Fig. 5** Distribution and abundance of acritarch and chitinozoa species: (r) indicates that the species is probably reworked from the Tremadoc or Cambrian.

from either the Manx assemblages or those from the Ogof Hên Formation. Furthermore, specimens of *Coryphidium* in the Glen Dhoo and Lonan Flags, referred previously to *C. bohemicum*, are probably not the same as Fennian specimens, having long, slender and flexible rather than short, conical and capitate processes.

Acritarchs of reported Arenig age are also known from Europe, north Africa, North America and Australia (Martin 1982). In a number of cases there is no independent evidence for an Arenig age, the age of the assemblages being inferred from their composition and comparisons with existing data. However, Rauscher (1973) has described acritarchs from the undivided *Didymograptus extensus* Biozone of the Montagne Noire, France, recording *Coryphidium bohe-*

*micum*, *Striatotheca rarirrugulata* and specimens of the '*V. trispinosum*' group. Comparison with south-west Wales suggests that the assemblage is probably of early Fennian age, implying that it is from the upper part of the *D. extensus* Biozone.

Vavrdova (1965, 1966, 1972, 1973, 1976) has described acritarchs from the Klabava Shales in the Rokycany district, 'U Starého hradu' ['at the old castle'] south-east of Klabava, Bohemia, where they occur in the *Tetragraptus* cf. *pseudobigsbyi* Biozone, a biostratigraphical unit that replaced the *T. reclinatus abbreviatus* Biozone (see Martin 1982: 35). The *Tetragraptus reclinatus abbreviatus* Biozone was regarded as being approximately equivalent to the *Isograptus gibberulus* Biosubzone of the British succession (Cooper & Fortey 1982: fig. 2), implying correlation with the Fennian. The acritarch assemblage 'U Starého hradu' includes *C. bohemicum* and the '*V. trispinosum*' group as well as a number of taxa not recorded from south-west Wales. Similarity between the two areas is apparently limited.

Arenig acritarchs from the upper part of the Bell Island Group and the overlying Wabana Group of Bell Island, eastern Newfoundland, have been recorded by Martin (*in* Dean & Martin 1978). Graptolites from approximately 20 m above the base of the Wabana Group are reported to indicate the upper part of the *D. extensus* Zone, implying a Fennian age. The acritarch assemblages have little in common with those from south-west Wales, containing thirty species of which six are recorded in this paper.

Acritarchs from equivalents of the Arenig Series in the Baltic region of the U.S.S.R. have been described by Timofeev (1959). The Baltic assemblages are unlike those from south-west Wales, where none of Timofeev's species have been recognized. The differences might arise from separation of the two areas across climatic zones in the Arenig, faunal evidence placing south-west Wales at high latitudes and the Baltic at temperate latitudes (Cocks & Fortey 1982).

No Arenig chitinozoa have hitherto been described from the British Isles, although Lister (*in* Arthurton & Wadge 1981) has reported chitinozoa from rocks of probable Arenig age in the Cross Fell Inlier. Post-Arenig chitinozoa have been described by Jenkins (1967) from the Hope Shales of Lower Llanvirn age in the Shelve Inlier of Shropshire. The specimens of *Conochitina* cf. *chydaea* and *Lagenochitina cylindrica*? that are present in Microfossil Assemblage VII resemble species recorded by Jenkins, but there is otherwise little in common with his Lower Llanvirn faunas. Many of the species that are characteristic of Llanvirn assemblages, notably species of *Siphonochitina*, are absent from the Pontyfenni Formation, as are other taxa such as *Cyathochitina campanulaeformis* and species of *Rhabdochitina* which range upwards from the Llanvirn. In contrast, the most common form in the Pontyfenni Formation, *Lagenochitina* sp. A, is apparently absent from the Hope Shales.

Arenig chitinozoa have been described from Quebec (Achab 1982), Spitsbergen (Bockelie 1980), Belgium (Martin 1969*a*), France (Rauscher 1968, 1973), north Africa (Benoit & Taugourdeau 1961), south-west Europe (Paris 1981), Australia (Combaz & Peniguel 1972) and Sweden (Grahn 1980). Further work, including scanning electron microscopy, is needed before comparisons can be made between these faunas and the chitinozoa from south-west Wales.

Very little comparison can be made with other areas, probably reflecting inadequate sampling for Arenig acritarchs and chitinozoa. Even this account is based on so few samples and such incomplete coverage that it should be regarded as preliminary. Martin (1982) notes that information from the Lower Arenig graptolite biozones of *Tetragraptus approximatus* and *Didymograptus deflexus* is sparse. It may be significant that many of the previously described assemblages are more similar to Microfossil Assemblage VI than any other, the earlier assemblages from south-west Wales occupying an interval that has not been sampled elsewhere.

## Systematic descriptions: Acritarchs

Figured specimens are deposited in the Palaeontological Collections of the British Geological Survey, Keyworth, and are registered in the series MPK 4870–4978.

Figure explanations include the specimen's register number (e.g. MPK 4971), details of the sample and an England Finder co-ordinate (e.g. K34/0) to locate the specimen on the slide. The co-ordinates were obtained on a Zeiss photomicroscope bearing the number 66303.

Acritarch genera and species are described alphabetically.

*Open nomenclature*. The genus name followed by 'sp. A', &c., is used when the species seems to be new but cannot be formally described on the available material. I use 'sp.' alone to indicate the material cannot be assigned to an existing species owing to poor preservation, or because the potentially diagnostic characters carry low taxonomic weight, requiring population study (for which there is insufficient material) to diagnose a new species, as against a variety of an existing species (as with *Striatotheca* sp., p. 346).

The use of '?' in different positions follows the convention of the British Geological Survey *Notes for Authors* (Dhonau 1982: 22).

## Genus *ACANTHODIACRODIUM* Timofeev, 1958

TYPE SPECIES. *Acanthodiacrodium dentiferum* Timofeev 1958.

### ***Acanthodiacrodium*** aff. ***angustum*** (Downie 1958) Combaz 1967
Fig. 6A, B

aff. 1958 *Diornatosphaera angusta* Downie: 345–346; pl. 17, figs 7, 8; text-fig. 3e.
aff. 1962 *Lophodiacrodium angustum* (Downie) Deflandre & Deflandre-Rigaud: 194.
aff. 1967 *Acanthodiacrodium angustum* (Downie) Combaz: 15; pl. 3, figs 67–72.

MATERIAL. One specimen.

OCCURRENCE. Cwmffrŵd Member: MPA 20077.

DESCRIPTION. The vesicle is ellipsoidal and opaque but more or less intact. About 20 short, rounded, densely crowded cones are present at each pole on the long axis of the vesicle.

DIMENSIONS. Vesicle diameter 37 × 30 $\mu$m; cone length less than 1 $\mu$m.

REMARKS. This specimen resembles the Tremadoc species *Acanthodiacrodium angustum* and morphologically similar species such as *Lophodiacrodium filiforme* (Timofeev) Deflandre & Deflandre-Rigaud. Poor preservation does not allow a positive identification.


**Fig. 6A, B** *Acanthodiacrodium* aff. *angustum* (Downie 1958) Combaz 1967, high and low focus; MPK 4870, sample MPA 20077, Cwmffrŵd Member; slide 2, J20/1, × 1200.

### ***Acanthodiacrodium*** aff. ***spinum*** Rasul 1979
Fig. 7A, B

aff. 1979 *Acanthodiacrodium spinum* Rasul: 66–67; pl. 3, figs 1–7.

MATERIAL. One specimen.

OCCURRENCE. Allt Cystanog Member: MPA 20074.

DESCRIPTION. The specimen is opaque but otherwise has suffered little damage. The vesicle is ellipsoidal with a slight equatorial constriction. The processes are short, flexible and tapering, and have evexate or capitate distal terminations. They may be solid or hollow. Approximately 25–30 processes are present at each pole.

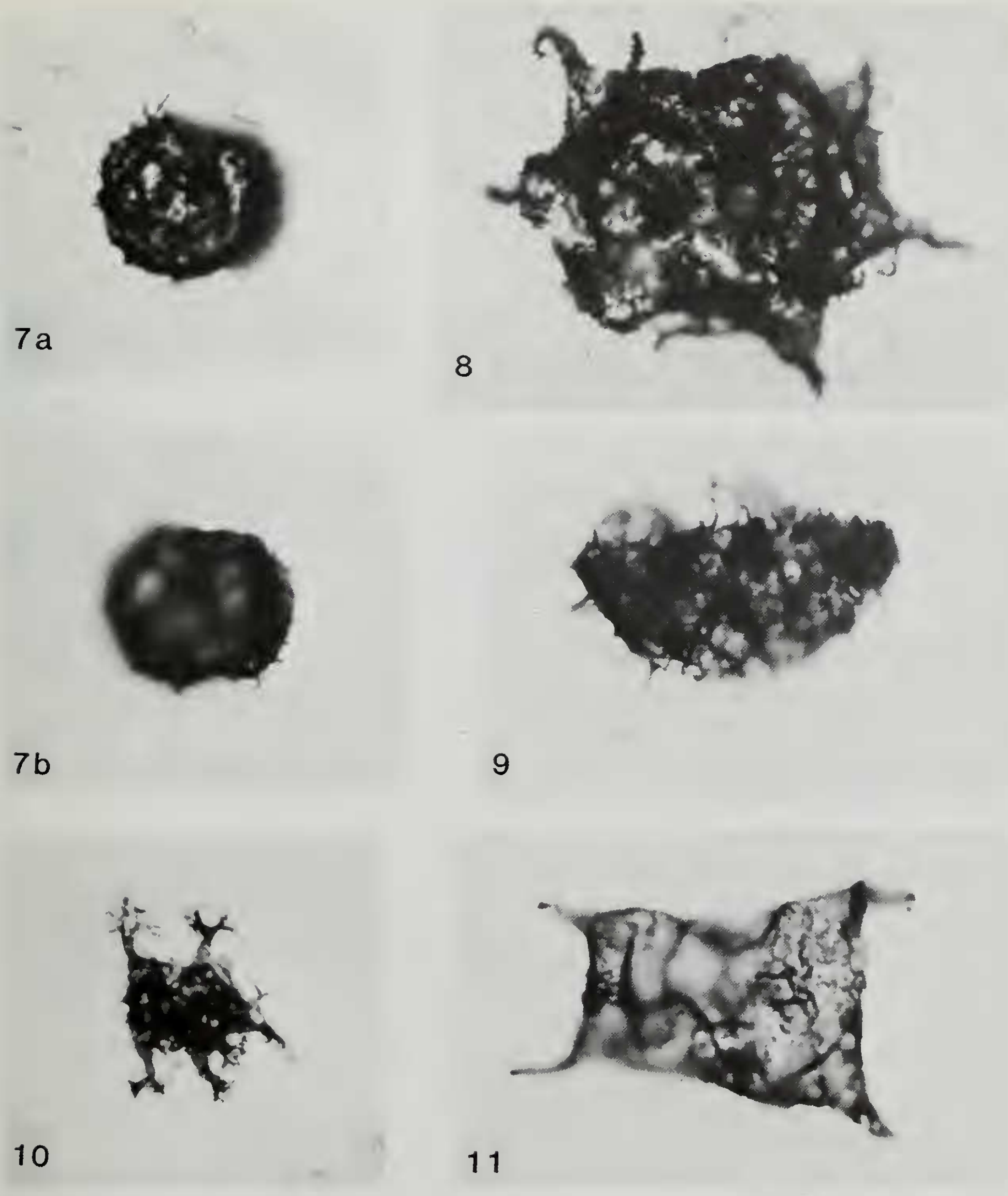


**Fig. 7A, B** *Acanthodiacrodium* aff. *spinum* Rasul 1979, high and low focus; MPK 4871, sample MPA 20074, Allt Cystanog Member; slide 2, N63/1, × 1200.

**Fig. 8** *Acanthodiacrodium* sp. A; MPK 4872, sample MPA 20087, Cwmffrŵd Member; slide 2, E24/0, × 1200.

**Fig. 9** *Baltisphaerosum* ? sp.; MPK 4873, sample MPA 20077, Cwmffrŵd Member; slide 2, U24/2, × 1200.

**Fig. 10** ?*Adorfia prolongata* Burmann 1970; MPK 4874, sample MPA 20093, Pontyfenni Formation; slide 1, P22/0, × 480. See Fig. 12.

**Fig. 11** *Barakella* sp. A; MPK 4875, sample MPA 20087, Cwmffrŵd Member; slide 1, E30/3, × 1200. See Fig. 13.

DIMENSIONS. Vesicle diameter 24 × 19 $\mu$m; process length 4 $\mu$m.

REMARKS. The gross morphology and dimensions of this specimen resemble those of *Acanthodiacrodium spinum*, described by Rasul (1979) from the *Clonograptus tenellus* Zone and Brachiopod Beds of the Tremadocian Shineton Shales. *A. spinum*, however, has hollow, acuminate processes and a finely striate vesicle.

### ***Acanthodiacrodium*** sp. A
Fig. 8

MATERIAL. One specimen.

OCCURRENCE. Cwmffrŵd Member: MPA 20087.

DESCRIPTION. The specimen is dark brown to grey and more or less intact. The vesicle is roughly hexagonal, but is drawn out along one axis. The processes are concentrated at the poles of the long axis, seven at one pole and four at the other. The processes are stout, conical, and together with the vesicle are covered by robust, hollow cones or hairs with solid tips. The narrow equatorial zone may be striate, the rather indistinct striae being parallel to the long axis of the vesicle.

DIMENSIONS. Vesicle diameter 40 × 33 $\mu$m; process length 12 $\mu$m.

REMARKS. The robust ornament distinguishes this specimen from most other species of *Acanthodiacrodium*. *A. achrasi* Martin, 1972, is similar but is smaller and has a finer ornament.

## Genus ***ADORFIA*** Burmann, 1970

TYPE SPECIES. *Adorfia firma* Burmann 1970.

### ? ***Adorfia prolongata*** Burmann 1970
Figs 10, 12

? 1970 *Adorfia prolongata* Burmann: 295; pl. 5, figs 1, 2, 5.
? 1978 *Adorfia prolongata* Burmann; Dean & Martin: 7; pl. 2, figs 6, 9; pl. 3, fig. 27.

MATERIAL. Two specimens.

OCCURRENCE. Pontyfenni Formation: MPA 20091, MPA 20093.

DESCRIPTION (based on one specimen from MPA 20093). The vesicle is subpolygonal to quadrate in outline. The process bases coalesce in part to mask the vesicle outline. Process stems are stout and cylindrical or slightly tapered. The processes divide distally by dichotomy, with up to five orders of division. The terminal branches on each process are long and recurved, and are apparently capitate. Nine processes are present.

DIMENSIONS. Vesicle diameter: 26 × 28 $\mu$m and 28 × 34 $\mu$m
Process length (overall): *c.* 20–25 $\mu$m
Process length (stem): *c.* 13–16 $\mu$m
Process width (base): 4–5 $\mu$m

REMARKS. The specimen from MPA 20093 apparently has capitate process terminations, a character diagnostic of the genus *Adorfia* Burmann. The dimensions of the vesicle and processes

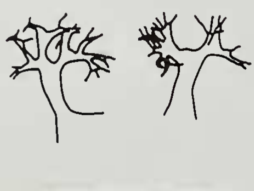


**Fig. 12** ?*Adorfia prolongata* Burmann 1970, detail of processes; MPK 4874. Bar represents 30 $\mu$m. See Fig. 10.

are consistent with those of *A. prolongata*, and the number of processes on the specimen falls within the range of variation recorded by Martin (*in* Dean & Martin 1978). Poor preservation precludes positive identification of the specimen.

### Genus *BALTISPHAEROSUM* Turner, 1984

TYPE SPECIES. *Baltisphaerosum christoferi* (Kjellstrom 1976) Turner 1984.

#### *Baltisphaerosum*? sp.
Fig. 9

MATERIAL. One specimen.

OCCURRENCE. Cwmffrŵd Member: MPA 20077.

DESCRIPTION. The specimen is hemispherical with a smooth or finely granulate wall. Its shape suggests that it is one half of a spherical vesicle which has split equatorially. About 30 short, slender, hollow and evexate processes, which are plugged at the base and do not communicate with the interior of the vesicle, are present.

DIMENSIONS. Vesicle diameter 40 × 20 $\mu$m; process length 7 $\mu$m.

REMARKS. The shape of the specimen suggests excystment by means of an equatorial split. Simple, hollow, proximally plugged processes and this type of excystment are diagnostic of *Baltisphaerosum*. Assignment to *Baltisphaerosum* is tentative, however, because this taxon is poorly recorded in the Arenig of south-west Wales, and also because it is difficult to be certain that the splitting is not the result of accidental damage. The specimen has much shorter processes than other known species of *Baltisphaerosum*.

### Genus *BARAKELLA* Cramer & Diez, 1977

TYPE SPECIES. *Barakella fortunata* Cramer & Diez 1977.

#### *Barakella* sp. A
Figs 11, 13

MATERIAL. One specimen.

OCCURRENCE. Cwmffrŵd Member: MPA 20087.

DESCRIPTION. The vesicle is rectangular and bears four processes, one at each corner. The processes are short and stout, with rounded distal terminations. The vesicle and processes are covered by short hairs or grana, and one of the two shorter sides of the vesicle has an area of short anastomosing hairs midway along its length.

DIMENSIONS. Vesicle diameter 36 × 24 $\mu$m; process length 8 $\mu$m.

REMARKS. The area of short anastomosing hairs is diagnostic of the genus but the ornament distinguishes this specimen from other species of *Barakella*.

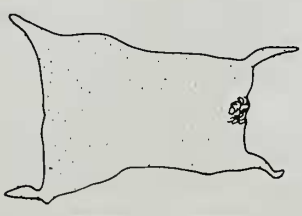


**Fig. 13** *Barakella* sp. A, detail of surface ornament and the structure midway along one of the two shorter sides; MPK 4875. Bar represents 30 $\mu$m. See Fig. 11.

## Genus *CORYPHIDIUM* Vavrdova, 1972

TYPE SPECIES. *Coryphidium bohemicum* Vavrdova 1972.

### *Coryphidium bohemicum* Vavrdova 1972
Figs 14–18, ? 20

1972 *Coryphidium bohemicum* Vavrdova: 84–85; pl. 1, figs 1, 2; text-fig. 4.

MATERIAL. Nine specimens.

OCCURRENCE. Pontyfenni Formation: MPA 20092–20100, 20102.

DESCRIPTION. The vesicle is quadrate with straight or concave sides and broadly rounded corners. Striations on the vesicle wall are more or less parallel to the sides of the vesicle. There are about 30 processes, concentrated at the corners of the vesicle, which have short, stout, conical stems and apparently hollow capitate distal terminations; the conical stems may be solid or hollow.

DIMENSIONS. Vesicle diameter: range 18–26 μm; mean 21 μm.
Process length: range 1·5–2·5 μm; mean 2 μm.
Process width: less than 1 μm.

REMARKS. The vesicles of the specimens from the Pontyfenni Formation conform to the diagnosis of *Coryphidium bohemicum*, but the processes are slightly shorter than those originally described by Vavrdova (1972). The distal process terminations of the Pontyfenni specimens are unlike any of the examples illustrated by Vavrdova, but as the processes of *C. bohemicum* are reported in the diagnosis to be distally heteromorphic, capitate terminations are not necessarily inconsistent with the determination. Specimens with predominantly capitate terminations on short, stout, conical stems appear to be characteristic of the Fennian; Booth (1979) illustrates a number of examples from the Fennian of north Wales, and Turner & Wadge (1979) illustrate three poorly preserved specimens with apparently similar processes from rocks of probable Fennian age in the Lake District. The specimens from the Pontyfenni Formation have fewer processes than the type material.

### ?*Coryphidium minutum* Cramer & Diez 1976
Fig. 19

?1976 *Coryphidium minutum* Cramer & Diez: 205; pl. 23, figs 7, 10; text-fig. 2: 7.

MATERIAL. One specimen.

OCCURRENCE. Allt Cystanog Member: MPA 20074.

DESCRIPTION. The specimen is split at one end but is otherwise undamaged. The vesicle is quadrate with more or less straight sides and broadly rounded corners. The vesicle wall is apparently smooth. The processes are more prominent at the corners of the vesicle but are not restricted to that position. They are relatively short, slender and bifid, and may be hollow. It is not clear whether the processes communicate with the interior of the vesicle. About 40 processes are present.

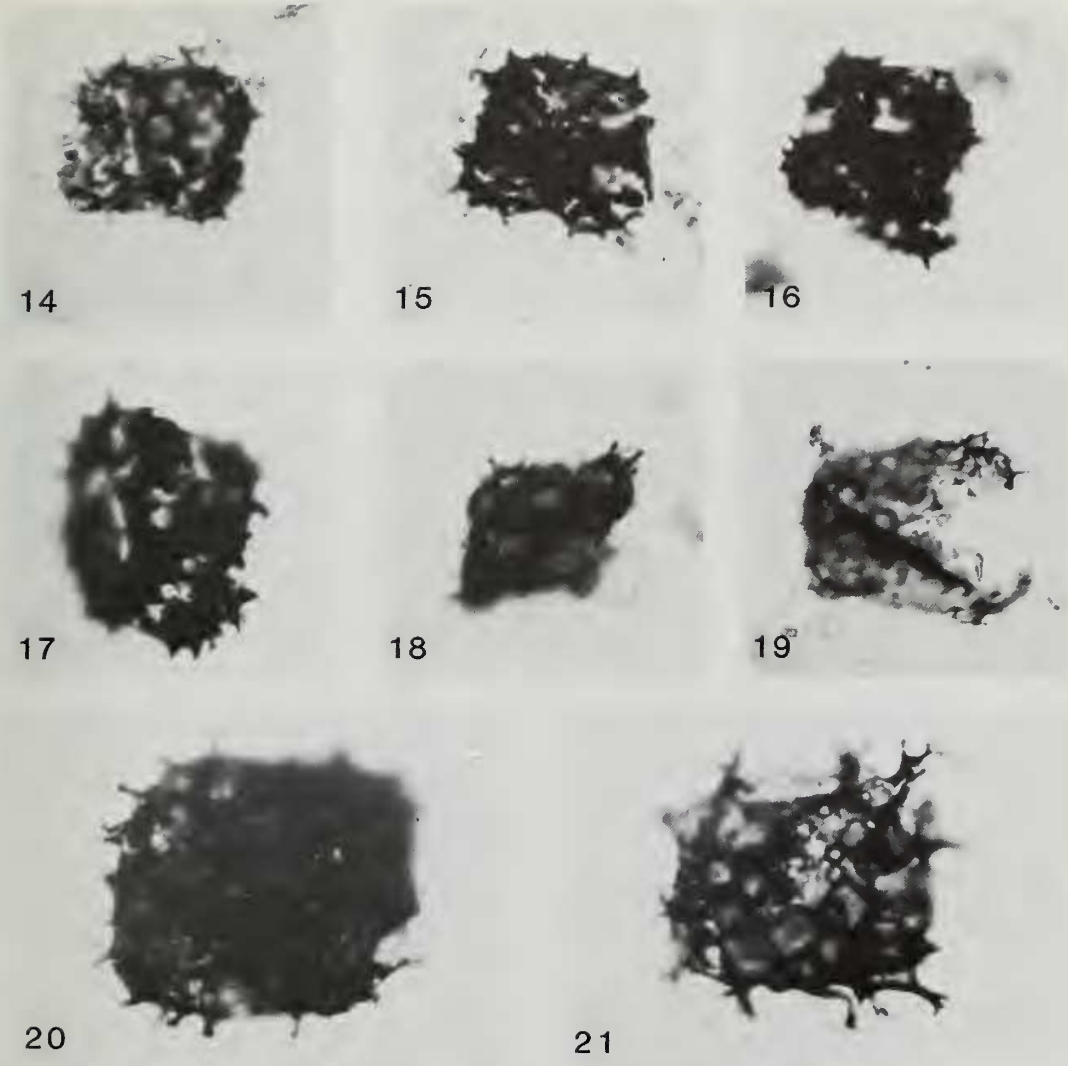
DIMENSIONS. Vesicle diameter 28 × 20 μm; process length 2·5 μm.

REMARKS. The specimen resembles *Coryphidium minutum* as illustrated by Cramer & Diez (1976) from rocks of alleged Upper Arenig age in Morocco. According to its diagnosis, *C. minutum* has slightly shorter processes with simple or capitate distal terminations.

### *Coryphidium*? sp. A
Figs 21–22

MATERIAL. One specimen.

OCCURRENCE. Cwmffrŵd Member: MPA 20087.




**Figs 14–18** *Coryphidium bohemicum* Vavrdova 1972. All Pontyfenni Formation; × 1200. Fig. 14, MPK 4876, sample MPA 20100; slide 1, W64/2. Fig. 15, MPK 4877, sample MPA 20102; slide 1, Q66/0. Fig. 16, MPK 4878, sample MPA 20102; slide 1, X74/4. Fig. 17, MPK 4879, sample MPA 20102; slide 1, M52/0. Fig. 18, MPK 4880, sample MPA 20092; slide 1, Q62/4.

**Fig. 19** ?*Coryphidium minutum* Cramer & Diez 1976; MPK 4881, sample MPA 20074, Allt Cystanog Member; slide 1, J49/3, × 1200.

**Fig. 20** *Coryphidium bohemicum*? Vavrdova 1972; MPK 4882, sample MPA 20093, Pontyfenni Formation; slide 1, P30/0, × 1200.

**Fig. 21** *Coryphidium*? sp. A; MPK 4883, sample MPA 20087, Cwmffrŵd Member; slide 1, H37/0, × 1200. See Fig. 22.

Description. The vesicle is quadrate with straight sides and broadly rounded corners. The vesicle wall is apparently smooth. The processes, which are concentrated at the corners of the vesicle, are stout and have elaborate distal terminations that bifurcate to the second order. The terminal branches of the processes may be capitate. Sixteen processes are present. Excystment may be by means of a straight split that occurs along one side of the vesicle.

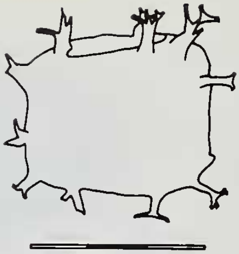


**Fig. 22** *Coryphidium*? sp. A; MPK 4883. Bar represents 30 $\mu$m. See Fig. 21.

DIMENSIONS. Vesicle diameter: 32 × 25 $\mu$m.
Process length: 7 $\mu$m.
Process width: 1·5 $\mu$m.

REMARKS. The vesicle has been distorted by crystal growth in the internal cavity but otherwise preservation is fair. The shape of the vesicle and the concentration of processes at the corners are characteristic of *Coryphidium*, but the specimen has longer and more elaborately branching processes than known species of that genus. The specimen may also differ from *Coryphidium* in its excystment mechanism. The split along one side is interpreted as a means of excystment whereas in the type species, *C. bohemicum*, it is reported to be by means of a large opening of irregular shape, usually oval or polygonal (Vavrdova 1972; Martin *in* Dean & Martin 1978). The genus *Tetraniveum* Vavrdova, 1976, has a similar vesicle shape and process arrangement, but the processes are simple.

## Genus *CYMATIOGALEA* Deunff, 1961

TYPE SPECIES. *Cymatiogalea margaritata* Deunff 1961.

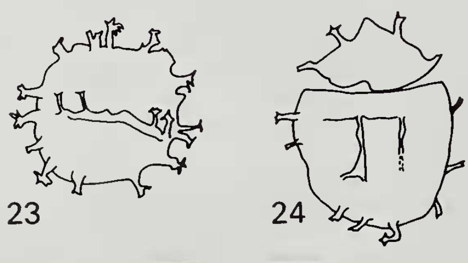
### *Cymatiogalea bellicosa* Deunff 1961
Fig. 25A, B

1961 *Cymatiogalea bellicosa* Deunff: 42; pl. 1, fig. 13.
1961 *Cymatiogalea pudica* Deunff: 42; pl. 1, fig. 4.
1964 *Cymatiogalea bellicosa* Deunff; Deunff: 122; pl. 1, figs 10–12, 16, 19–20.

MATERIAL. One specimen.

OCCURRENCE. Pontyfenni Formation: MPA 20099.

DESCRIPTION. The vesicle is hemispherical, with a large polar opening (macropyle). The processes are stout and cylindrical, dividing distally into several short branches, all of which are of the first order, arising from a common point on the stem. The processes show some variation in length, the longer ones being situated opposite the macropyle while those nearer the opening are much shorter. The processes support a veil.




**Figs 23, 24** *Cymatiogalea*? sp.; sample MPA 20077, Cwmffrŵd Member; bar represents 30 $\mu$m. Fig. 23, MPK 4885; slide 2, N24/0. See Fig. 26. Fig. 24, MPK 4886; slide 2, V25/4. See Fig. 27.

DIMENSIONS. Vesicle diameter: 26 × 36 μm; process length 8 μm opposite macropyle, decreasing to 3 μm near macropyle.

REMARKS. *Cymatiogalea bellicosa* is widespread in rocks of Tremadoc age. In Britain, it occurs in the lower part of the Shineton Shales, of early Tremadoc age, in Shropshire (Rasul 1974, 1979). Its presence in the Pontyfenni Formation indicates probable reworking.

***Cymatiogalea*? sp.**
Figs 23–24, 26–27

MATERIAL. Three specimens.

OCCURRENCE. Cwmffrŵd Member: MPA 20077.

DESCRIPTION. The vesicles are subspherical, and that of one specimen (Figs 24, 27) may be divided into polygonal fields; this specimen may also have a macropyle. The processes are short, hollow, and cylindrical, and are plugged at the base so that the process interiors do not communicate with the vesicle cavity. They are usually divided distally into four or five filaments, but on one specimen (Figs 23, 26) they have more elaborately branched distal terminations which divide to the second order.

DIMENSIONS. Vesicle diameter: range 24–36 μm; mean 29 μm.
Process length: range 3–5 μm; mean 4 μm.

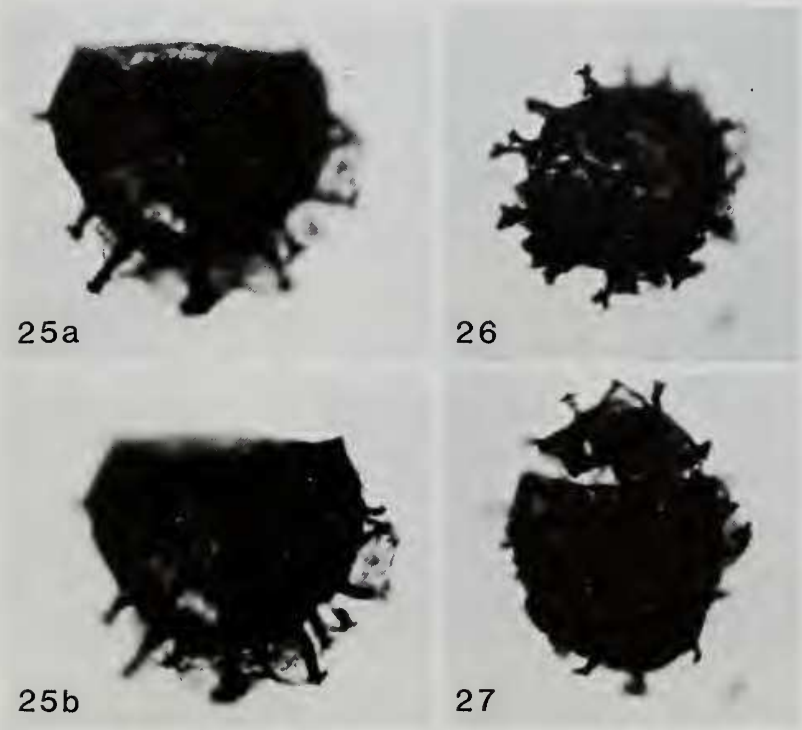



**Fig. 25A, B** *Cymatiogalea bellicosa* Deunff 1961; MPK 4884, sample MPA 20099, Pontyfenni Formation; slide 1, S34/3, × 1200.
**Figs 26, 27** *Cymatiogalea*? sp.; × 1200. Fig. 26, MPK 4885. See Fig. 23. Fig. 27, MPK 4886. See Fig. 24.

REMARKS. Assignment of these three specimens to *Cymatiogalea* is based on the apparent presence of a macropyle and polygonal fields on one specimen. These characters are diagnostic of the genus according to the emended diagnosis given by Deunff *et al.* (1974). The determination is tentative because of poor preservation.

### Genus *DASYDORUS* Playford & Martin, 1984

TYPE SPECIES. *Dasydorus cirritus* Playford & Martin 1984.

#### *Dasydorus cirritus*? Playford & Martin 1984
Figs 28–43

?1984 *Dasydorus cirritus* Playford & Martin: 198, fig. 6A–C.

MATERIAL. Eighteen specimens.

OCCURRENCE. Pontyfenni Formation: MPA 20091–3.

DESCRIPTION. The vesicle is subtriangular or egg-shaped. One end, usually the narrower, is smooth and is acutely rounded or is drawn out into a short apical protuberance. The rest of the vesicle is covered by numerous randomly distributed, short, stiff and evexate or capitate hairs. Excystment may have been by means of a longitudinal split, either alone or in combination with loss of the smooth apical region.

DIMENSIONS. Vesicle length: range 38–58 $\mu$m; mean 49 $\mu$m.
Vesicle width: range 32–48 $\mu$m; mean 37 $\mu$m.
Length of hairs: less than 2–2·5 $\mu$m.

REMARKS. The specimens are very similar to those described and figured by Playford & Martin (1984), but the smooth apex is more acutely rounded and in some cases is developed into a short protuberance. These albeit slight morphological differences, and the difference in preservation, disallow a confident identification until more is known about the morphology and occurrence of the species.

The excystment mechanism of *Dasydorus* is unknown but four specimens from the Pontyfenni Formation (Figs 33–36, 41–43) provide some evidence. Each shows a longitudinal split, accompanied on one specimen by loss of the smooth apical region. Given their state of preservation, it is difficult to eliminate incidental damage as its cause, but the consistent appearance of the split suggests that it may be a true excystment opening.

Playford & Martin (1984) note that the genus *Pirea* Vavrdova differs from *Dasydorus* by possessing a distinct apical process. The short apical protuberance on some of the Welsh specimens resembles this process, suggesting a possible relationship between the two genera.

### Genus *FRANKEA* Burmann, 1970

TYPE SPECIES. *Frankea hamata* Burmann 1970.

#### ?*Frankea hamata* Burmann 1970
Fig. 44

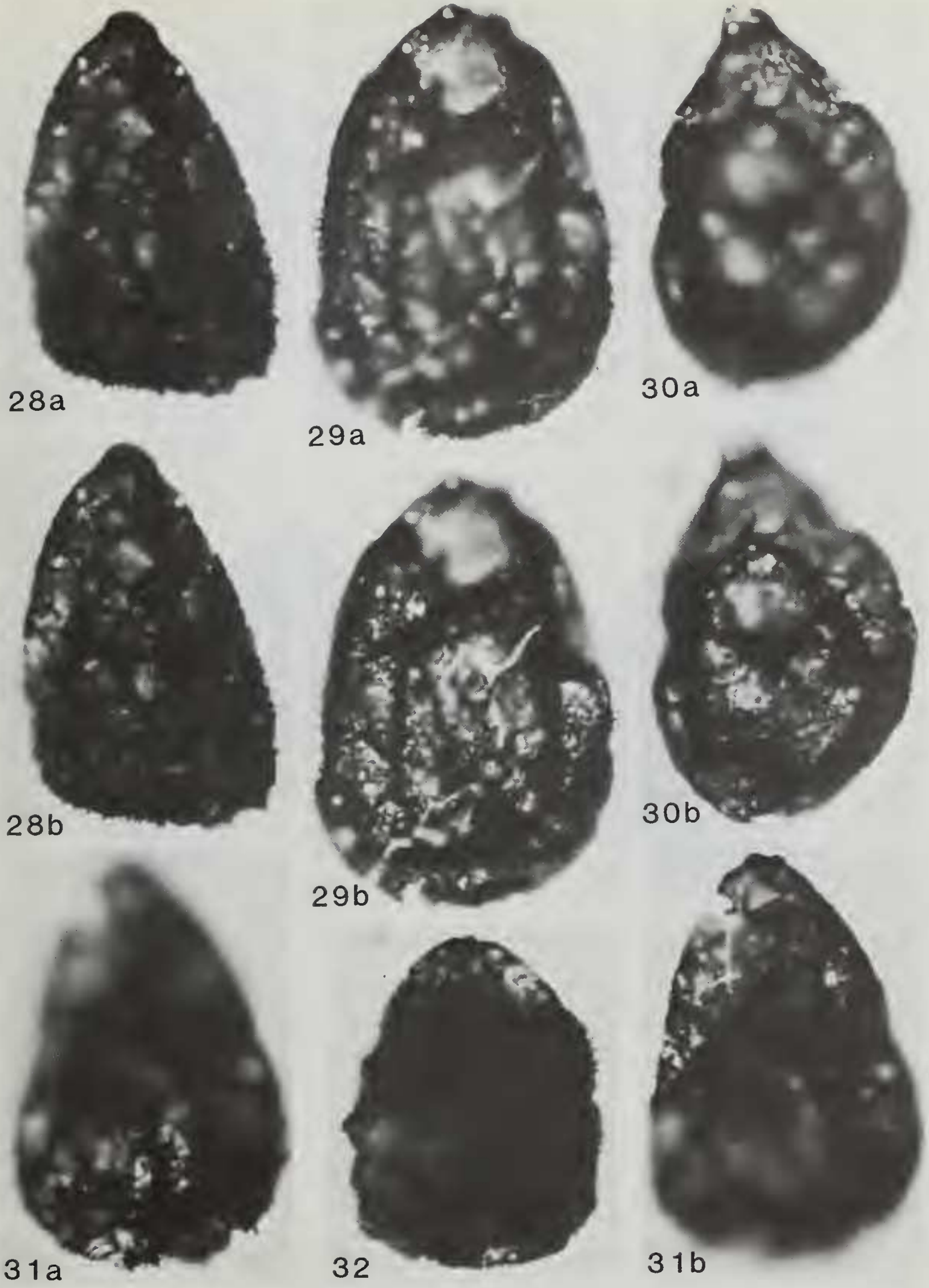
?1970 *Frankea hamata* Burmann: 290–291; pl. 2, figs 7, 9, 10.

MATERIAL. One damaged specimen.

OCCURRENCE. Pontyfenni Formation: MPA 20102.

DESCRIPTION. The vesicle is broken but was probably triangular. Two processes are present, situated at two corners of the triangle; the third corner is broken. The processes are short and divide distally. One process divides into two long, recurved filaments.

DIMENSIONS. Vesicle diameter 24 × 20 $\mu$m; process length 4 $\mu$m.




**Figs 28–32** *Dasydorus cirritus*? Playford & Martin 1984. All Pontyfenni Formation; × 1200. Fig. 28A, B, high and low focus; MPK 4915, sample MPA 20091; slide 1, J28/1. See Fig. 39. Fig. 29A, B, high and low focus; MPK 4916, sample MPA 20092; slide 2, Q34/0. See Fig. 37. Fig. 30A, B, specimen with protuberance resembling apical horn, high and low focus; MPK 4917, sample MPA 20093; slide 1, J31/4. See Fig. 40. Fig. 31A, B, high and low focus; MPK 4918, sample MPA 20092; slide 1, W36/0. Fig. 32, MPK 4919, sample MPA 20091; slide 1, D35/1. See Fig. 38.


**Figs 33–36** Excystment mechanism of *Dasydorus cirritus*? Playford & Martin 1984. All sample MPA 20092, Pontyfenni Formation; × 1200. Fig. 33, specimen with longitudinal split; MPK 4920; slide 1, E24/0. Fig. 34, specimen with partial longitudinal split developing at the antapex; MPK 4921; slide 1, F56/2. See Fig. 41. Fig. 35, specimen with partial longitudinal split restricted to one side of the vesicle and also exhibiting loss of the apical region; MPK 4922; slide 1, K24/1. See Fig. 43. Fig. 36, specimen with partial longitudinal split developing at the antapex; MPK 4923; slide 2, K34/2. See Fig. 42.

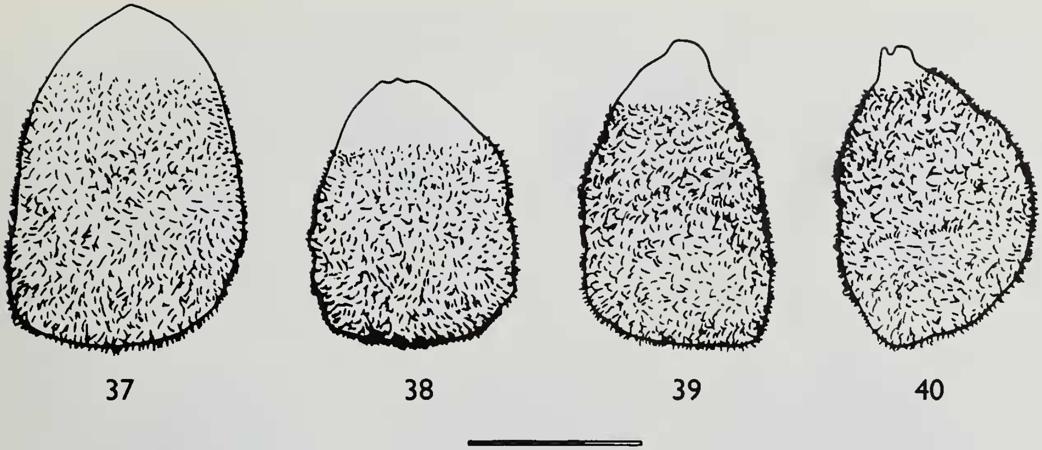
REMARKS. Identification of the specimen is tentative because of damage to the vesicle. Even so, the probable shape of the vesicle and the distal terminations of the processes are characteristic of *Frankea hamata*, and the determination is probably correct. The processes are shorter than those of the type specimen (Burmann 1970).

Genus ***MICRHYSTRIDIUM*** Deflandre, 1937

TYPE SPECIES. *Micrhystridium inconspicuum* Deflandre 1937.

***Micrhystridium*** aff. ***acuminosum*** Cramer & Diez 1977
Figs 45–47, 70

aff. 1977 *Micrhystridium acuminosum* Cramer & Diez: 347; pl. 1, figs 3, 4, 10; text-fig. 3: 3.



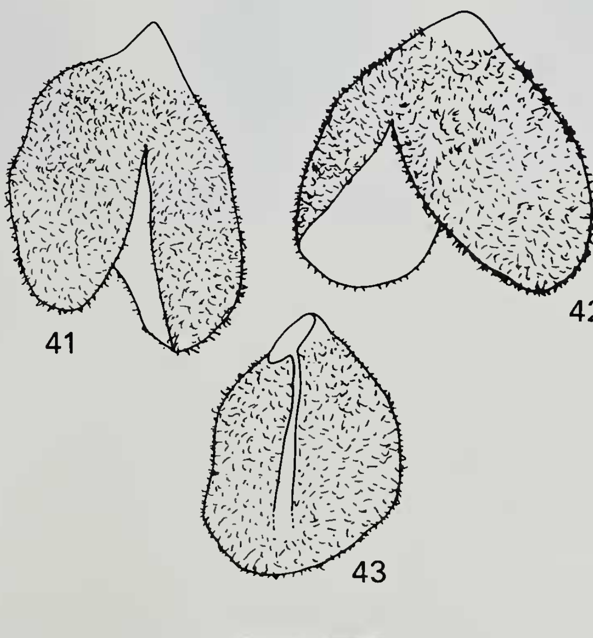
37 38 39 40

**Figs 37–40** *Dasydorus cirritus*? Playford & Martin 1984. Bar represents 30 $\mu$m. Fig. 37, MPK 4916. See Fig. 29. Fig. 38, MPK 4919. See Fig. 32. Fig. 39, MPK 4915. See Fig. 28. Fig. 40, MPK 4917. See Fig. 30.

MATERIAL. Three specimens.

OCCURRENCE. Allt Cystanog Member: MPA 20074.

DESCRIPTION. The vesicle is small and subspherical. The outline of the vesicle is partially masked by the process bases. The processes are numerous, relatively short and conical, extending distally into acuminate, needle-like tips.



41 42 43

**Figs 41–43** Excystment mechanism of *Dasydorus cirritus*? Playford & Martin 1984. Bar represents 30 $\mu$m. Fig. 41, MPK 4921. See Fig. 34. Fig. 42, MPK 4923. See Fig. 36. Fig. 43, MPK 4922. See Fig. 35.

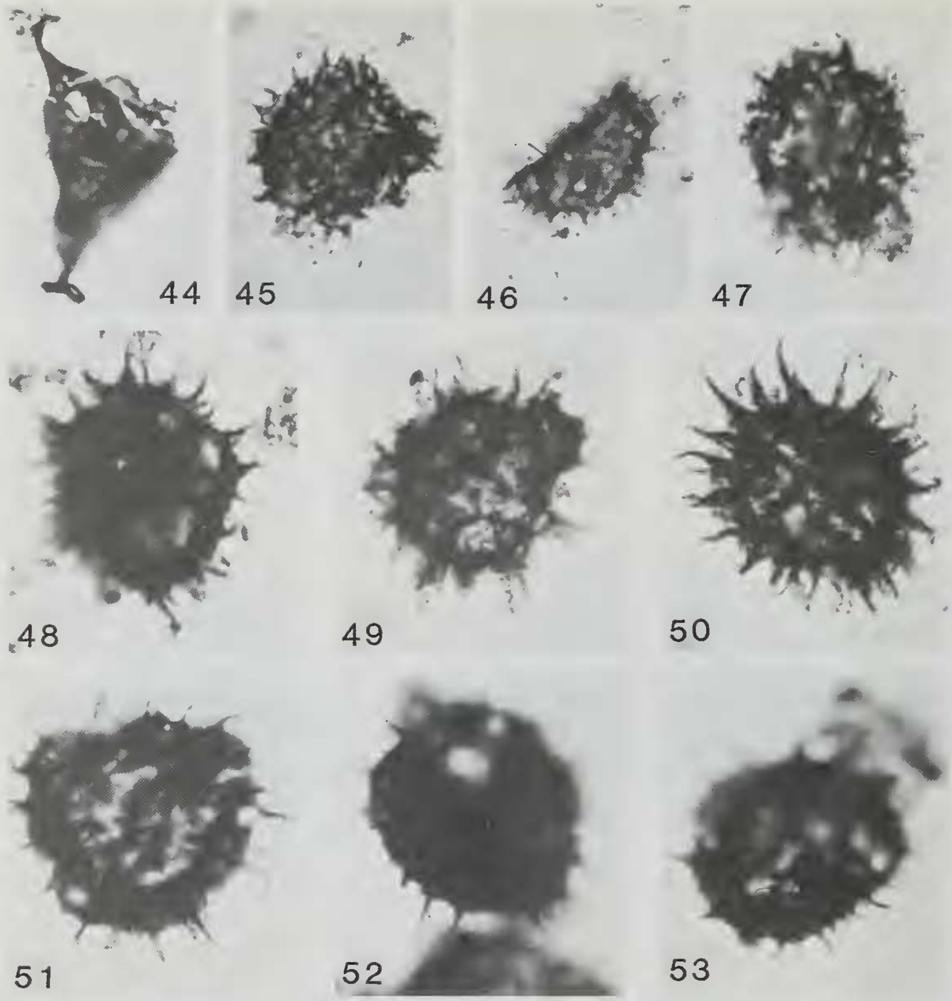



**Fig. 44** ?*Frankea hamata* Burmann 1970; MPK 4887, sample MPA 20102, Pontyfenni Formation; slide 1, R54/3, × 1200.

**Figs 45–47** *Micrhystridium* aff. *acuminosum* Cramer & Diez 1977; sample MPA 20074, Allt Cystanog Member; × 1200. Fig. 45, MPK 4888; slide 2, H70/2. See Fig. 70. Fig. 46, MPK 4889; slide 1, S53/3. Fig. 47, MPK 4890; slide 1, H71/0.

**Figs 48–50** *Micrhystridium* cf. *inconspicuum aremoricanum* Paris & Deunff 1970; × 1200. Fig. 48, MPK 4891, sample MPA 20103, Cwm yr Abbey Member; slide 2, L57/3. Fig. 49, MPK 4892, sample MPA 20103, Cwm yr Abbey Member; slide 2, D74/2. Fig. 50, MPK 4893, sample MPA 20104, Afon Ffinnant Formation; slide 2, L51/2. See Fig. 74.

**Figs 51–53** *Micrhystridium* aff. *henryi* Paris & Deunff 1970; sample MPA 20103, Cwm yr Abbey Member; × 1200. Fig. 51, MPK 4894; slide 2, H74/2. Fig. 52, MPK 4895; slide 2, V70/1. See Fig. 73. Fig. 53, MPK 4896; slide 2, R53/1.

Dimensions. Vesicle diameter range 10–22 $\mu$m, mean 18 $\mu$m; process length 3 $\mu$m.

Remarks. The processes on each of the three specimens resemble those of *Micrhystridium acuminosum* and suggest an affinity with that species, although *M. acuminosum* has a larger vesicle and longer, stouter processes.

### *Micrhystridium* aff. *henryi* Paris & Deunff 1970
Figs 51–53, 73

aff. 1970 *Micrhystridium henryi* Paris & Deunff: 31–32; pl. 2, figs 2, 10, 14, 15, 18; pl. 3, fig. 7.

MATERIAL. Five specimens.

OCCURRENCE. Cwm yr Abbey Member: MPA 20103. Afon Ffinnant Formation: MPA 20104.

DESCRIPTION. The vesicle is subspherical with about 30–40 processes. The sides of the vesicle between the process bases are straight or slightly curved; if curved they may be either concave or convex. The processes taper from narrow bases to acuminate distal terminations.

DIMENSIONS. Vesicle diameter range 20–26 μm, mean 23 μm; process length 4–5 μm.

REMARKS. The small, subspherical vesicles and numerous, relatively short processes suggest a relationship between these specimens and *Micrhystridium henryi*. *M. henryi* has shorter and more numerous processes, their bases coalescing to mask the outline of the vesicle. Specimens from the Fennian of north Wales, referred by Booth (1979) to *M. henryi*, are closer to this material from south-west Wales than to the type material, but have slightly shorter processes.

### *Micrhystridium* cf. *inconspicuum aremoricanum* Paris & Deunff 1970
Figs 48–50, 74

cf. 1970 *Micrhystridium inconspicuum aremoricanum* Paris & Deunff: 32; pl. 2, fig. 20.

MATERIAL. Twenty-one specimens.

OCCURRENCE. Cwm yr Abbey Member: MPA 20084, MPA 20103. Afon Ffinnant Formation: MPA 20104.

DESCRIPTION. The vesicle is small and subspherical, bearing about 30 processes. The processes are simple, relatively short, acuminate and narrowly conical. Their bases tend to coalesce, masking the outline of the vesicle.

DIMENSIONS. Vesicle diameter range 14–24 μm, mean 19 μm; process length range 3·5–8 μm, mean 5 μm.

REMARKS. The material from south-west Wales is very similar to the type material of *Micrhystridium inconspicuum aremoricanum* and to specimens recorded by Booth (1979), but the processes of the specimens from south-west Wales are commonly about a quarter of the vesicle diameter in length, rarely a third or more. The original diagnosis states that the processes are about a third of the vesicle diameter, and Booth also records the length as being approximately a third. The difference is slight but may distinguish the present specimens from the type and Booth's material.

The type material of *M. inconspicuum aremoricanum* was recorded from the base of the Andouillé Formation north of Rennes (Paris 1981: 19), considered to be of Llanvirn age (Babin *et al.* 1974: 365). Booth's material came from the Fennian of north Wales and the Llanvirn of the Welsh Borderland and Lake District. In south-west Wales, *M.* cf. *inconspicuum aremoricanum* appears in the upper Moridunian, but has not been recorded from the Whitlandian or Fennian.

### *Micrhystridium* aff. *nannacanthum* Deflandre 1945
Figs 54–57, 71

aff. 1942 *Micrhystridium nannacanthum* Deflandre: 476; fig. 13 (nomen nudum).
aff. 1945 *Micrhystridium nannacanthum* Deflandre: 66; pl. 3, figs 5–7.

MATERIAL. Thirteen specimens.

OCCURRENCE. Cwm yr Abbey Member: MPA 20084, MPA 20103.

DESCRIPTION. The vesicle is small and subspherical, bearing about 30 short, hair-like processes. The processes are slender, parallel-sided, possibly solid and are evexate or capitate.

DIMENSIONS. Vesicle diameter range 12–22 μm, mean 16 μm; process length less than 2 μm.

REMARKS. According to the diagnosis (Deflandre 1945), *Micrhystridium nannacanthum* has short spines that do not exceed 1 μm in length. The specimens from south-west Wales are distinct, in that they have slightly longer processes, some having distinctive rounded or capitate distal terminations. They also have larger vesicles than the type material. A specimen illustrated by Lister (1970: pl. 10, fig. 11) from the late Silurian of Shropshire also differs from the present material, having a smaller vesicle with shorter, stouter and fewer processes. Booth (1979) has recorded several specimens of ?*M. nannacanthum* from the Fennian of north Wales and the Llanvirn of the Lake District. His specimens resemble these from the Cwm yr Abbey Member but he notes that his have numerous, short, evenly distributed, conical spines which have either blunt or acuminate distal terminations. In south-west Wales, *M.* aff. *nannacanthum* has only been recorded from the upper Moridunian.

***Micrhystridium*** **sp. A**
Figs 58–59, 66

MATERIAL. Six specimens.

OCCURRENCE. Whitland Abbey Member: MPA 20098.

DESCRIPTION. The vesicle is small and subspherical. Its outline is largely masked by the processes, the bases of which tend to coalesce. The processes are short, stout, cylindrical or slightly tapered, with either evexate or acuminate distal terminations. The sides of the vesicle, where visible between the process bases, are straight or concave. About 20 processes are present.

DIMENSIONS. Vesicle diameter range 10–16 μm, mean 12 μm; process length less than 2–2·5 μm.

REMARKS. *Micrhystridium* sp. A may be distinguished from *M.* aff. *nannacanthum* by its smaller size and longer, relatively stout processes and from *Micrhystridium* spp. B–D by its cylindrical rather than conical processes.

***Micrhystridium*** **sp. B**
Figs 60–61, 67

MATERIAL. Six specimens.

OCCURRENCE. Whitland Abbey Member: MPA 20098.

DESCRIPTION. The vesicle is small and subspherical. Its outline is masked by the process bases, which tend to coalesce. The processes are numerous, short, conical and acuminate.

DIMENSIONS. Vesicle diameter range 9–15 μm, mean 12 μm; process length less than 2 μm.

REMARKS. It is difficult to determine the number of processes present on each specimen because of poor preservation, but there are probably more than thirty.

***Micrhystridium*** **sp. C**
Figs 62–63, 68

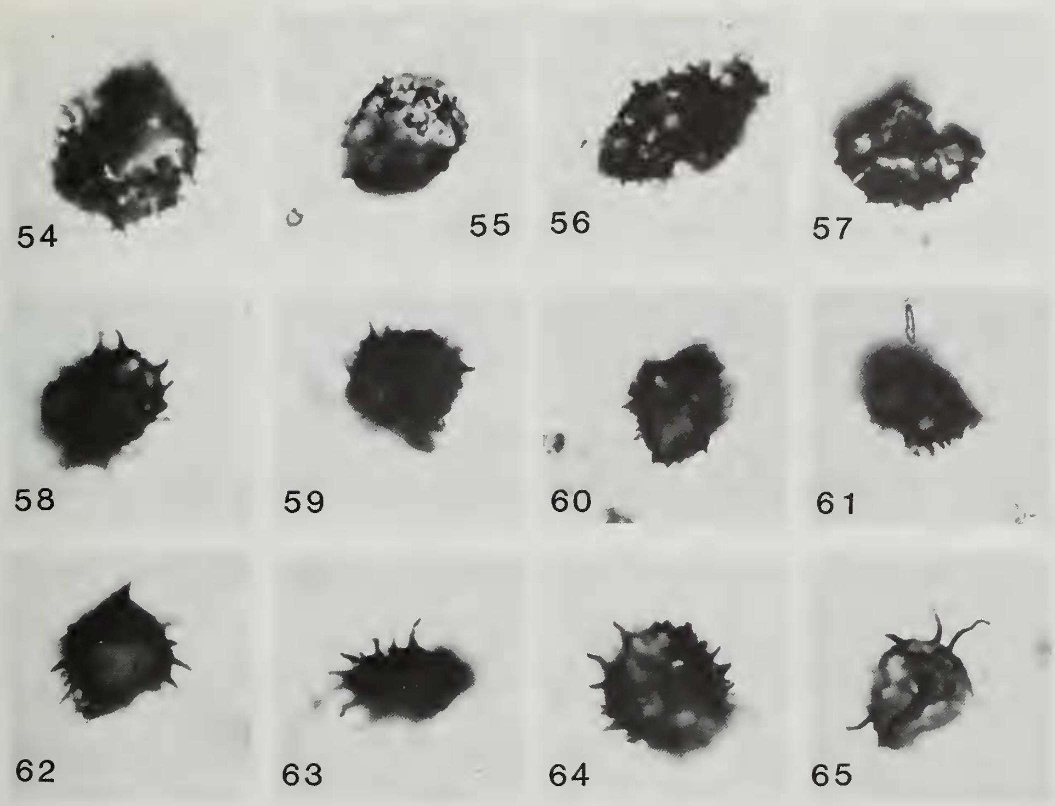
MATERIAL. Seven specimens.

OCCURRENCE. Whitland Abbey Member: MPA 20098.

DESCRIPTION. The vesicle is small and subspherical. The processes are numerous, slender, tapering and acuminate. Their bases tend to mask the outline of the vesicle, but where visible the sides are convex.

DIMENSIONS. Vesicle diameter range 8–16 μm, mean 13 μm; process length range 3–5 μm, mean 3·5 μm.

REMARKS. The exact number of processes is uncertain because of poor preservation, but is probably 25 or more. *Micrhystridium* sp. C may be distinguished from *Micrhystridium* sp. B by its longer processes.




**Figs 54–57** *Micrhystridium* aff. *nannacanthum* Deflandre 1945; sample MPA 20084, Cwm yr Abbey Member; × 1200. Fig. 54, MPK 4897; slide 2, T55/3. See Fig. 71. Fig. 55, MPK 4898; slide 2, T64/2. Fig. 56, MPK 4899; slide 2, W54/0. Fig. 57, MPK 4900; slide 2, X66/4.

**Figs 58, 59** *Micrhystridium* sp. A; sample MPA 20098, Whitland Abbey Member; × 1200. Fig. 58, MPK 4901; slide 1, W62/2. See Fig. 66. Fig. 59, MPK 4902; slide 1, B57/2.

**Figs 60, 61** *Micrhystridium* sp. B; sample MPA 20098, Whitland Abbey Member; × 1200. Fig. 60, MPK 4903; slide 1, N60/4. See Fig. 67. Fig. 61, MPK 4904; slide 1, S52/2.

**Figs 62, 63** *Micrhystridium* sp. C; sample MPA 20098, Whitland Abbey Member; × 1200. Fig. 62, MPK 4905; slide 1, S55/1. See Fig. 68. Fig. 63, MPK 4906; slide 1, R60/1.

**Fig. 64** *Micrhystridium* sp. D; MPK 4907, sample MPA 20098, Whitland Abbey Member; slide 1, R53/2, × 1200. See Fig. 69.

**Fig. 65** *Micrhystridium* sp.; MPK 4908, sample MPA 20098, Whitland Abbey Member; slide 1, P64/3, × 1200. See Fig. 72.

### *Micrhystridium* sp. D
Figs 64, 69

MATERIAL. Two specimens.

OCCURRENCE. Whitland Abbey Member: MPA 20098.

DESCRIPTION. The vesicle is small and subspherical, its sides masked by the process bases which tend to coalesce. The processes are numerous, short, conical and acuminate.

DIMENSIONS. Vesicle diameter range 13–16 $\mu$m, mean 15 $\mu$m; process length range 2–3 $\mu$m, mean 2·5 $\mu$m.

REMARKS. The exact number of processes is uncertain owing to poor preservation, but one specimen has at least 40. *Micrhystridium* sp. D may be distinguished from *Micrhystridium* sp. B by its longer, more numerous processes, and from *Micrhystridium* sp. C by its shorter, more numerous processes.

**_Micrhystridium_ sp.**
Figs 65, 72

MATERIAL. One specimen.

OCCURRENCE. Whitland Abbey Member: MPA 20098.

DESCRIPTION. The specimen has a small, subspherical vesicle with convex sides. Eight processes are present. They are long, slender, possibly solid and evexate, tapering slightly from narrow bases that have an angular contact with the vesicle wall. The vesicle diameter is 14 × 12 μm and process length is approximately 7 μm.

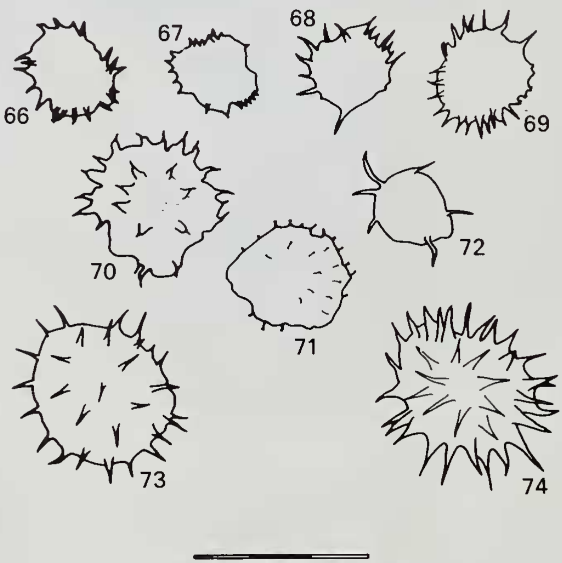
Genus ***NOTHOOIDIUM*** Loeblich & Tappan, 1976

TYPE SPECIES. *Nothooidium mordidum* (Cramer, Allam, Kanes & Diez 1974) Loeblich & Tappan 1976.

**_Nothooidium_? spp.**
Figs 75–76

MATERIAL. Two specimens.

OCCURRENCE. Afon Ffinnant Formation: MPA 20104. Pontyfenni Formation: MPA 20101.




**Figs 66–74** *Micrhystridium* spp., comparative illustrations of specimens recorded from the Arenig Series in south-west Wales. Bar represents 30 μm. Fig. 66, *Micrhystridium* sp. A; MPK 4901. See Fig. 58. Fig. 67, *Micrhystridium* sp. B; MPK 4903. See Fig. 60. Fig. 68, *Micrhystridium* sp. C; MPK 4905. See Fig. 62. Fig. 69, *Micrhystridium* sp. D; MPK 4907. See Fig. 64. Fig. 70, *Micrhystridium* aff. *acuminosum* Cramer & Diez 1977; MPK 4888. See Fig. 45. Fig. 71, *Micrhystridium* aff. *nannacanthum* Deflandre 1945; MPK 4897. See Fig. 54. Fig. 72, *Micrhystridium* sp.; MPK 4908. See Fig. 65. Fig. 73, *Micrhystridium* aff. *henryi* Paris & Deunff 1970; MPK 4895. See Fig. 52. Fig. 74, *Micrhystridium* cf. *inconspicuum aremoricanum* Paris & Deunff 1970; MPK 4893. See Fig. 50.

DESCRIPTIONS. The specimen from the Afon Ffinnant Formation (Fig. 75) has an elongate, pear-shaped vesicle, one end of which is concave suggesting the presence of an opening. The ornament consists of grana and short, conical, evexate and possibly solid processes. The vesicle of this specimen is 48 μm long and 36 μm wide.

The specimen from the Pontyfenni Formation (Fig. 76) has a similar elongate, pear-shaped vesicle, one end of which is concave, and an ornament of cones and rods with evexate distal terminations. The vesicle of this specimen is 45 μm long and 40 μm wide.

REMARKS. The two specimens are very similar and may represent the same species, although the processes on the specimen from the Pontyfenni Formation are longer and more slender than those on the Afon Ffinnant specimen. Determination of both specimens as *Nothooidium* is tentative because the poor preservation makes it difficult to demonstrate that the truncated ends of the vesicles are cyclopylomes. *N. mordidum* is smaller and has an ornament that consists of flat-crested verrucae. *Ooidium* sp. 2 of Cramer & Diez (1977: pl. 6, fig. 20) is very similar but is only illustrated and not described.

## Genus ***ORTHOSPHAERIDIUM*** Eisenack, 1968

TYPE SPECIES. *Orthosphaeridium rectangulare* (Eisenack 1963) Eisenack 1968.

### ***Orthosphaeridium ternatum*** (Burmann 1970) Eisenack, Cramer & Diez 1976
Fig. 77A, B

1970 *Baltisphaera ternata* Burmann: 306; pl. 7, fig. 1; pl. 9, fig. 4.
1976 *Orthosphaeridium ternatum* (Burmann) Eisenack, Cramer & Diez: 529.

MATERIAL. Four specimens.

OCCURRENCE. Pontyfenni Formation: MPA 20091, MPA 20093.

DESCRIPTION. The vesicle is subspherical with three long, slender, acuminate processes which are arranged at *c.* 120° intervals around the circumference. They are constricted slightly towards the base. Both vesicle and processes bear an ornament of short hairs or cones.

DIMENSIONS. Vesicle diameter range 48–60 μm, mean 52 μm; process length up to 76 μm.

REMARKS. The specimens are poorly preserved but are readily determined as *Orthosphaeridium ternatum*. *O. procerum* (Burmann) Eisenack *et al.* 1976 has a more asymmetrical arrangement of processes.

### ***Orthosphaeridium*** sp.
Fig. 79

MATERIAL. One specimen.

OCCURRENCE. Pontyfenni Formation: MPA 20101.

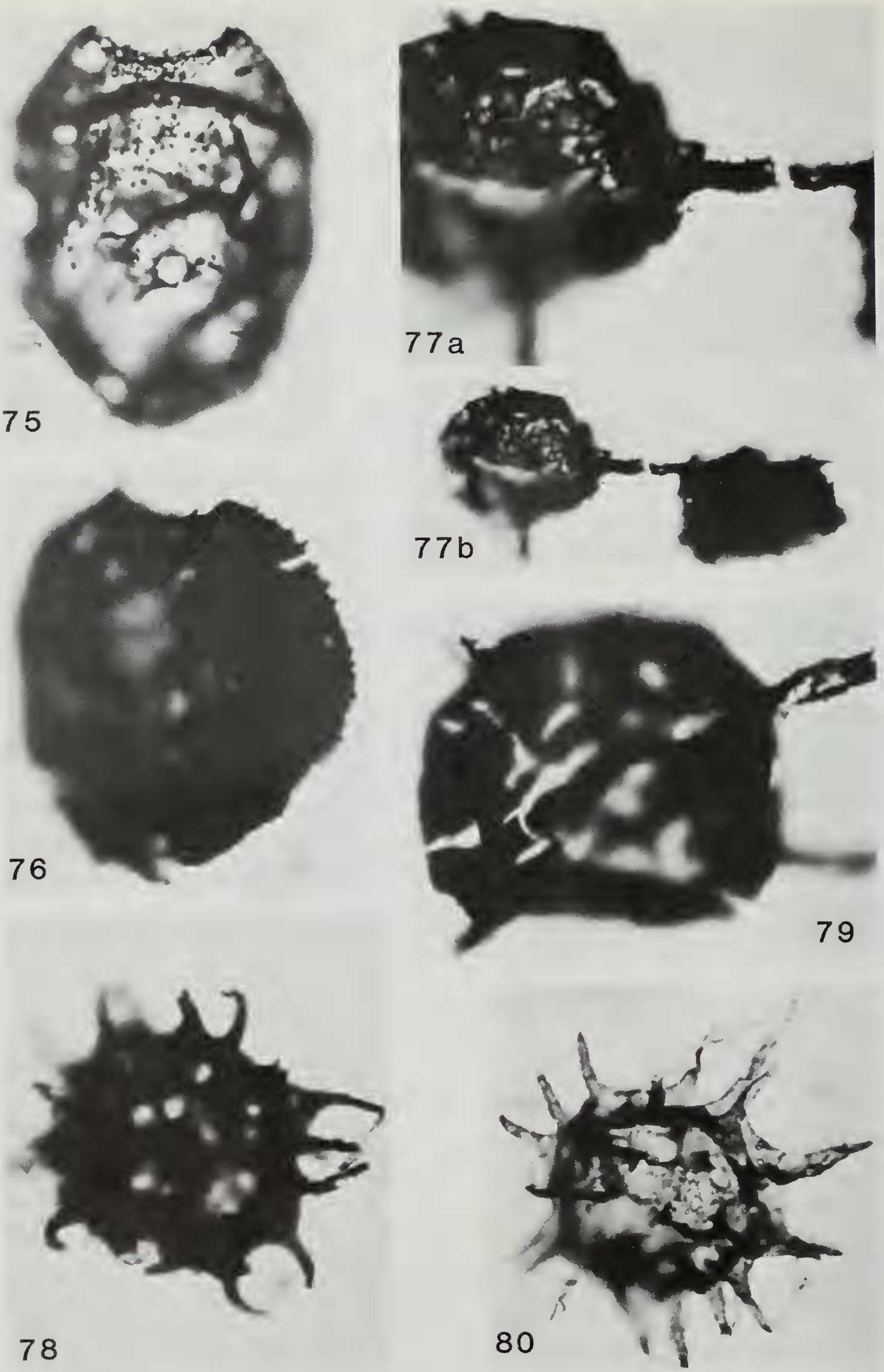
DESCRIPTION. The vesicle is subspherical with four processes, all broken. The process stems are stout and are constricted towards the base. Both vesicle and processes have an ornament of short, robust hairs.

DIMENSIONS. Vesicle diameter 50 × 43 μm.

REMARKS. This specimen resembles *Orthosphaeridium quadrinatum* (Burmann) Eisenack, Cramer & Diez 1976, but its poor preservation precludes a positive determination.

## Genus ***POLYGONIUM*** Vavrdova, 1966

TYPE SPECIES. *Polygonium gracile* Vavrdova 1966.


75
77a
77b
76
79
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80

### *Polygonium* sp. A
Figs 80–81

MATERIAL. Two specimens, plus several fragments.

OCCURRENCE. Allt Cystanog Member: MPA 20074.

DESCRIPTION. The outline of the vesicle is subpolygonal. The sides of the vesicle are straight or concave; occasionally they may be masked by the wide process bases. The processes are long, tapering and evexate. The proximal half of each process is relatively stout and thick-walled, while the distal half is thinner-walled and flexible. The difference between the two halves is quite distinct, the change taking place abruptly. The distal half of the process may break away leaving a straight or V-shaped distal edge. About 25 processes are present on one specimen.

DIMENSIONS. Vesicle diameter range 26–30 μm, mean 28 μm; process length *c.* 18 μm.

REMARKS. The description is based on one specimen from the Allt Cystanog Member (MPA 20074); a number of fragments in the same sample have similar features. One specimen may also be present in the Cwmffrŵd Member (MPA 20077) but the preservation is too poor to be certain.

### *Polygonium* sp. B
Fig. 78

MATERIAL. Six specimens.

OCCURRENCE. Cwm yr Abbey Member: MPA 20084.

DESCRIPTION. The vesicle is large and subspherical with a polygonal outline. The sides of the vesicle are straight or concave; occasionally they may be masked by the broad process bases. The processes are long, stout, flexible, tapering and acuminate; about 20 are present.

DIMENSIONS. Vesicle diameter range 24–36 μm, mean 31 μm; process length range 14–16 μm, mean 15 μm.

REMARKS. Most specimens are broken and their preservation is poor. The size and polygonal outline of the vesicle and the relatively long, stout processes are distinctive.

## Genus *SOLISPHAERIDIUM* Staplin, Jansonius & Pocock, 1965

TYPE SPECIES. *Solisphaeridium stimuliferum* (Deflandre 1938) Staplin, Jansonius & Pocock 1965.

### *Solisphaeridium* sp. A
Figs 82–83, 86

MATERIAL. Four specimens.

OCCURRENCE. Pontyfenni Formation: MPA 20091.

DESCRIPTION. The vesicle is subspherical with convex sides. The processes are long, slender, smooth, evexate, moderately flexible, solid and slightly tapering. They number more than 40 on each specimen.

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**Figs 75, 76** *Nothooidium* sp.; × 1200, Fig. 75, MPK 4909, sample MPA 20104, Afon Ffinnant Formation; slide 2, G54/0. Fig. 76, MPK 4910, sample MPA 20101, Pontyfenni Formation; slide 1, G28/0.

**Fig. 77A, B** *Orthosphaeridium ternatum* (Burmann 1970) Eisenack, Cramer & Diez 1976; A × 1200, B × 480; MPK 4911, sample MPA 20091, Pontyfenni Formation; slide 1, X41/0.

**Fig. 78** *Polygonium* sp. B; MPK 4912, sample MPA 20084, Cwm yr Abbey Member; slide 2, Y30/4, × 1200.

**Fig. 79** *Orthosphaeridium* sp.; MPK 4913, sample MPA 20101, Pontyfenni Formation; slide 1, S26/2, × 1200.

**Fig. 80** *Polygonium* sp. A; MPK 4914, sample MPA 20074, Allt Cystanog Member; slide 2, U42/4, × 1200. See Fig. 81.

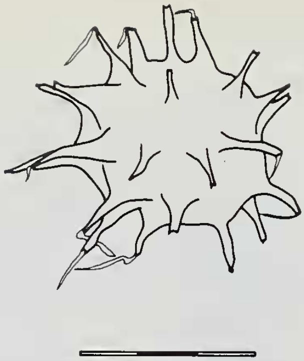
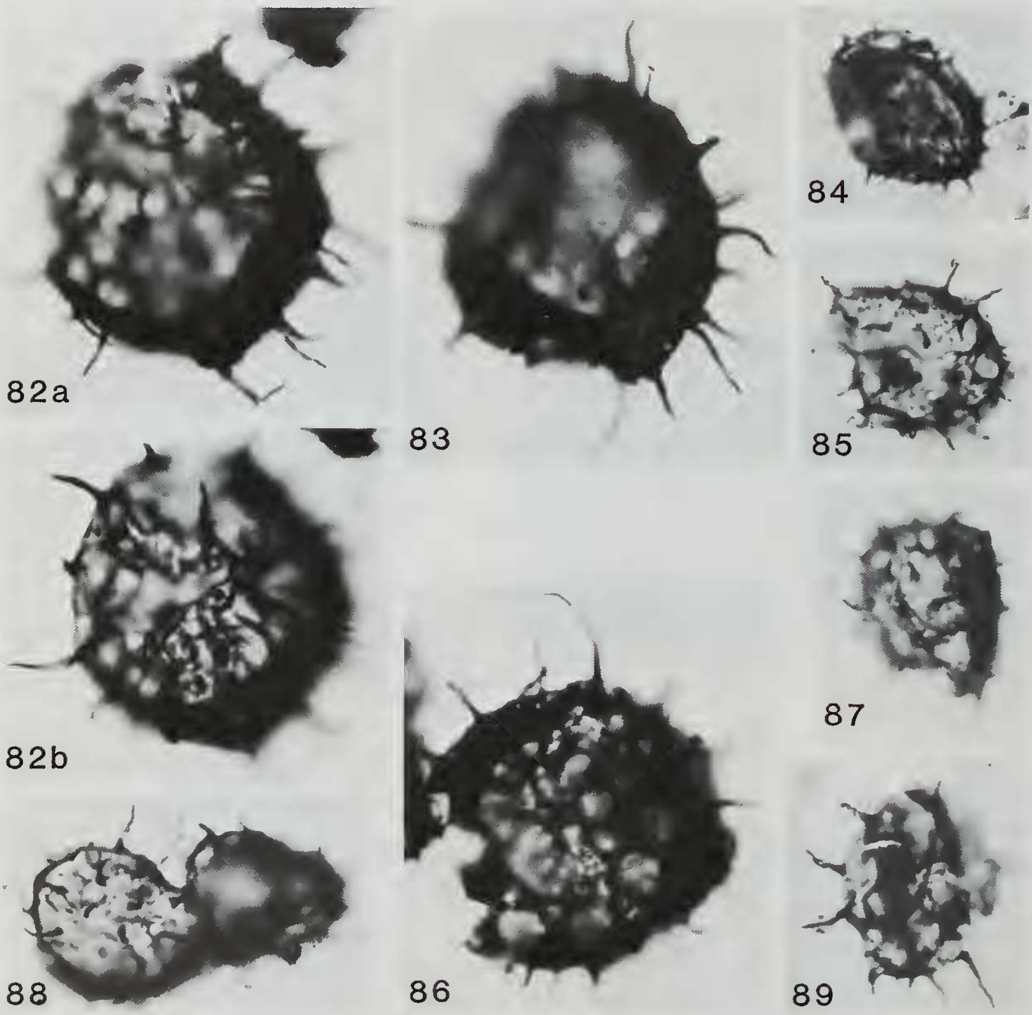


**Fig. 81** *Polygonium* sp. A; MPK 4914. See Fig. 80. Bar represents 30 $\mu$m.




**Figs 82, 83, 86** *Solisphaeridium* sp. A; sample MPA 20091, Pontyfenni Formation; × 1200. Fig. 82A, B, high and low focus; MPK 4924; slide 1, U27/1. Fig. 83, MPK 4925; slide 1, P43/4. Fig. 86, MPK 4928; slide 1, Q28/3.

**Figs 84, 85, 87–89** *Solisphaeridium* sp. B; Cwm yr Abbey Member; × 1200. Figs 84, 85, 87, sample MPA 20103. Fig. 84, MPK 4926; slide 2, N58/2. Fig. 85, MPK 4927; slide 2, Q53/3. Fig. 87, MPK 4929; slide 2, Q75/3. Figs 88, 89, sample MPA 20084. Fig. 88, MPK 4930; slide 2, X59/4. Fig. 89, MPK 4931, slide 2, X51/4.

Dimensions. Vesicle diameter range 34–43 $\mu$m, mean 37 $\mu$m; process length range 11–20 $\mu$m, mean 14 $\mu$m.

Remarks. Superficially, the specimens resemble two species of *Solisphaeridium* described by Cramer & Diez (1977) from the Upper Arenig of Morocco. *S. solare* has a smaller vesicle and relatively long, stout processes, while *S. solidispinosum* is distinguished by its numerous, acuminate, conical processes.

**Solisphaeridium** sp. B
Figs 84–85, 87–89

Material. Six specimens.

Occurrence. Cwm yr Abbey Member: MPA 20084, MPA 20103.

Description. The vesicle is subspherical and has a granulate wall. The sides of the vesicle between the process bases are convex, rarely concave. Numerous short, slender, tapering, acuminate and possibly solid processes are present.

Dimensions. Vesicle diameter range 17–24 $\mu$m, mean 21 $\mu$m; process length range 2–8 $\mu$m, mean 5 $\mu$m.

Remarks. The short processes and the nature of the ornament on the vesicle distinguish these specimens from the type and other species of *Solisphaeridium.* The specimens from MPA 20084 have about 15–20 processes, their lengths being more or less equal to a third of the vesicle diameter. Those from MPA 20103 differ slightly, in that they have more than 30 processes with an average length of less than a fifth of the vesicle diameter. Since relatively few specimens have been recorded and their preservation is poor, these differences are not used to separate the specimens from the two samples.

The specimens bear a strong resemblance to *Baltisphaeridium cinctum* (Timofeev) Rauscher (*in* Rauscher 1973: 71; pl. 2, figs 7a–b) but have smaller vesicles.

Genus ***STELLECHINATUM*** Turner, 1984

Type species. *Stellechinatum celestum* (Martin 1969*b*) Turner 1984.

***Stellechinatum papulessum*** sp. nov.
Figs 90–92

Diagnosis. A species of *Stellechinatum* with eight to ten processes, which are wide and conical at the base but cylindrical distally. The processes, and possibly the vesicle, bear an ornament of very small grana.

Holotype. MPK 4932 (Figs 90–1): MPA 20091, Pontyfenni Formation.

Other material. Twelve specimens, paratypes.

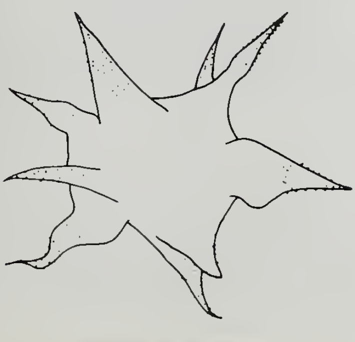


**Fig. 90** *Stellechinatum papulessum* sp. nov., **holotype**; MPK 4932, sample MPA 20091, Pontyfenni Formation; slide 1, O39/3. Bar represents 30 $\mu$m. See Fig. 91.

OCCURRENCE. Pontyfenni Formation: MPA 20091–3.

NAME. 'Small pimple or pustule', referring to the fine ornament.

DESCRIPTION. The outline of the vesicle is variable. On some specimens, the sides of the vesicle are masked by the wide, coalescing process bases; on others, the sides of the vesicle are clearly visible, resulting in a polygonal outline. The processes are wide and conical at the base, becoming more cylindrical distally. They taper to an evexate distal termination. A slight constriction is rarely present at the base of the distal, cylindrical part of the process. The average process length is just over half of the vesicle diameter.

DIMENSIONS. Vesicle diameter: range 24–36 μm; mean 29 μm.
Process length: range 14–21 μm; mean 17 μm.
Process width (at base): range 6–11 μm; mean 9 μm.

REMARKS. Several specimens are distorted by the growth of crystals within the vesicle cavity.

The type species, *Stellechinatum celestum* (Martin) Turner, has a similar outline, similar vesicle dimensions and approximately the same number of processes with wide bases. It is distinguished from *S. papulessum* sp. nov. by its relatively long, acuminate processes and its ornament of slender spines on the processes and vesicle. *S. helosum* Turner 1984 has comparable vesicle dimensions and a similar ornament but has longer and more numerous acuminate processes with narrower bases. *S. brachyscolum* Turner 1984 has more numerous processes with an ornament of long spines. *Goniosphaeridium splendens* (Paris & Deunff) Turner 1984 has a similar gross morphology, but has a smooth wall and more numerous processes.

### ***Stellechinatum uncinatum*** (Downie 1958) comb. nov.
Figs 93–94

1958 *Hystrichosphaeridium longispinosum* var. *uncinatum* Downie: 337; text-fig. 2a.
1965 *Baltisphaeridium longispinosum* var. *uncinatum* (Downie) Downie & Sarjeant: 92.
1965 *Baltisphaeridium uncinatum* (Downie) Martin: 425–426; text-fig. 1.
1970 *Micrhystridium uncinatum* (Downie) Cramer: 107–108; pl. 6, figs 97–98, 101; text-fig. 29d (*pars*).
*non* 1971 *Goniosphaeridium uncinatum* (Martin) Kjellström: 27–28; fig. 18 [*err. cit. pro Goniosphaeridium uncinatum* (Downie) Kjellström].

MATERIAL. Seven specimens.

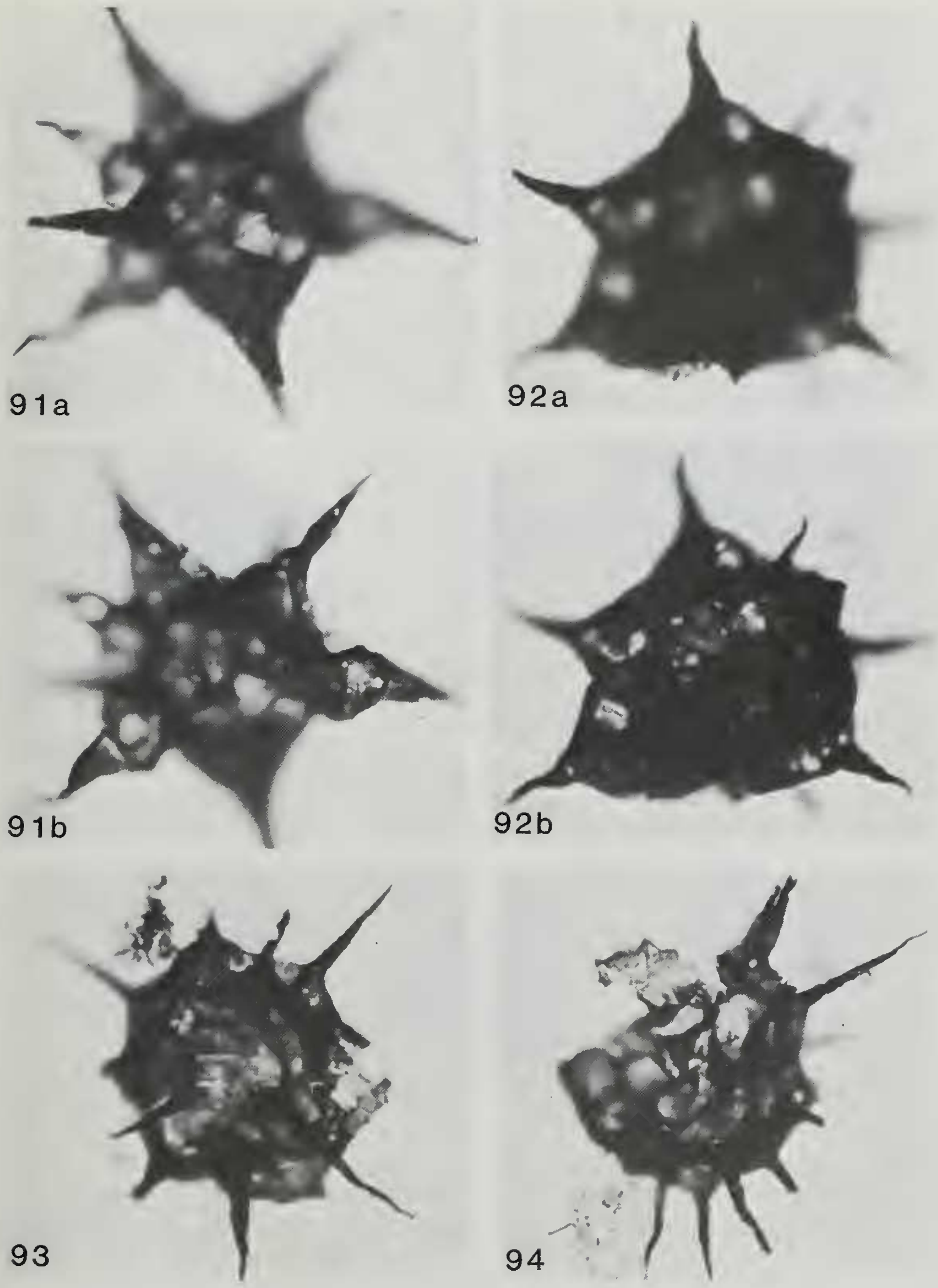
OCCURRENCE. Pontyfenni Formation: MPA 20099, MPA 20101, MPA 20093.

DESCRIPTION. The vesicle is polygonal or subpolygonal in outline, with more or less straight sides. There are about 15 processes, which are slender, tapering, acuminate and may be solid. They have relatively narrow bases, bear an ornament of short spines, and are just over half the vesicle diameter in average length.

DIMENSIONS. Vesicle diameter: range 22–32 μm; mean 29 μm.
Process length: range 15–18 μm; mean 17 μm.
Process width (at base): 2·5–3 μm.

REMARKS. The holotype of *Hystrichosphaeridium longispinosum* var. *uncinatum* Downie (1958: fig. 2a) has a polygonal vesicle with several tapering, acuminate processes, the latter bearing short lateral hairs. The species is morphologically comparable with the genus *Stellechinatum* Turner and is here recombined with it.

Turner (1984) describes *Stellechinatum* as having wide process bases. In contrast, on the holotype of *S. uncinatum* (Downie) comb. nov. they are relatively narrow. Other species of *Stellechinatum*, notably *S. brachyscolum* Turner 1984 and *S. helosum* Turner 1984, have process bases of variable width, the narrower bases being comparable with those of *S. uncinatum* (Downie) comb. nov. *S. helosum* is distinguished from *S. uncinatum* (Downie) comb. nov. by its ornament of grana rather than of spines on the processes. *S. brachyscolum* has more processes than *S. uncinatum*, their conical bases coalescing to form the vesicle outline.




**Figs 91–92** *Stellechinatum papulessum* sp. nov.; sample MPA 20091, Pontyfenni Formation; × 1200. Fig. 91A, B, **holotype**, high and low focus; MPK 4932; slide 1, O39/3. See Fig. 90. Fig. 92A, B, high and low focus; MPK 4933; slide 1, N41/1.

**Figs 93–94** *Stellechinatum uncinatum* (Downie 1958) comb. nov.; sample MPA 20099, Pontyfenni Formation; × 1200. Fig. 93, MPK 4934; slide 1, R30/2. Fig. 94, MPK 4977; slide 1, M35/3.

Three of the specimens illustrated by Cramer (1970: pl. 6, figs 97–98, 101) are unlike *S. uncinatum* (Downie) comb. nov., two having subspherical vesicles and relatively long processes, the third fewer processes that, together with the vesicle, are covered by an ornament of relatively coarse spines. Only the text-figure (Cramer 1970: text-fig. 29d) bears some resemblance to the holotype and to the material illustrated herein. The specimen illustrated by Kjellström (1971: fig. 18), from the Middle Ordovician of Gotland, has more numerous processes with broad, conical bases and is comparable with *Stellechinatum brachyscolum* from the Caradoc of England.

### Genus ***STELLIFERIDIUM*** Deunff, Gorka & Rauscher, 1974

Type species. *Stelliferidium striatulum* (Vavrdova 1966) Deunff, Gorka & Rauscher 1974.

#### ***Stelliferidium*** aff. ***fimbrium*** (Rasul 1974) Rasul 1979
Figs 95, 97

aff. 1974 *Priscogalea fimbria* Rasul: 47; pl. 3, figs 1–2.
aff. 1979 *Stelliferidium fimbrium* (Rasul) Rasul: 69.

Material. Two specimens.

Occurrence. Pontyfenni Formation: MPA 20091–2.

Description. The vesicle is subspherical and granulate, and has a large polar opening (macropyle). About 20–25 processes are present; they are hollow and cylindrical but it is not clear if they communicate with the vesicle cavity. Distally, they divide into three or four long, recurved branches that lie at a tangent to the surface of the vesicle. Striations radiate from the base of each process across the surface of the vesicle.

Dimensions. Vesicle diameter range 26–28 $\mu$m, mean 27 $\mu$m; process length range 5–8 $\mu$m.

Remarks. The specimens resemble the Tremadoc species *Stelliferidium fimbrium* (Rasul) Rasul but are smaller and may have more robust distal terminations.

### Genus ***STRIATOTHECA*** Burmann, 1970

Type species. *Striatotheca principalis* Burmann 1970.

#### ? ***Striatotheca mutua*** Burmann 1970
Fig. 96A, B

?1970 *Striatotheca mutua* Burmann: 301; pl. 11, fig. 2.
?1978 *Striatotheca mutua* Burmann: Dean & Martin; 9; pl. 2, figs 12, 13; pl. 3, fig. 18.

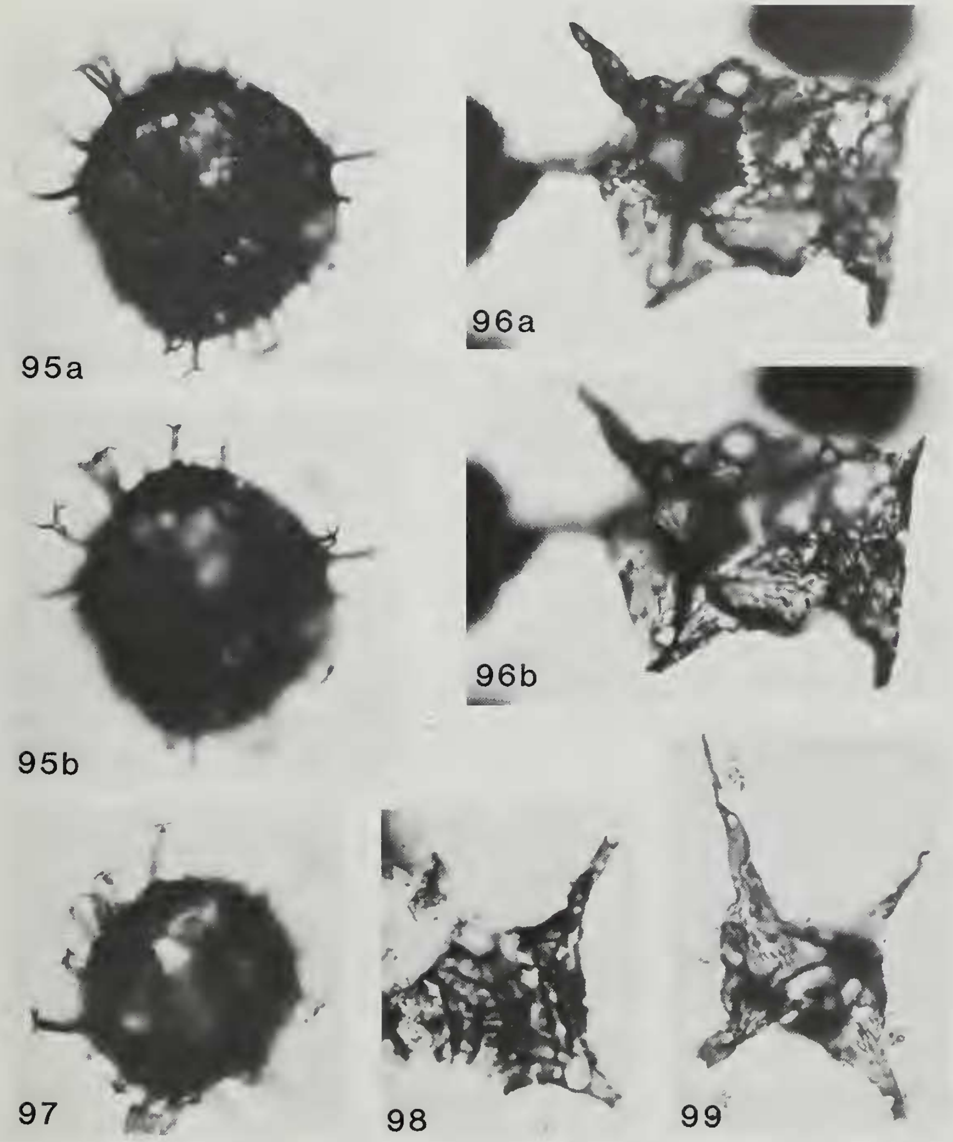
Material. One specimen.

Occurrence. Pontyfenni Formation: MPA 20099.

Description. The vesicle is elongate and pentagonal in outline. Two processes are present but the total number may have been five or six; they are relatively short, conical and evexate. Striations extend from the base of each process and are more or less parallel to the five sides of the vesicle.

Dimensions. Vesicle diameter $38 \times 26$ $\mu$m; process length 18 $\mu$m.

Remarks. The holotype (Burmann 1970: pl. 11, fig. 2) has a more or less rectangular outline with three processes at each pole on the long axis. The diagnosis also refers to the vesicle as being four-sided. The processes on the holotype are longer than those on the present specimen from the Pontyfenni Formation. Martin (*in* Dean & Martin 1978) describes the vesicle of *S. mutua* as being polyhedral, and although she remarks that the outline is quadrangular, one specimen (Dean & Martin 1978: pl. 3, fig. 18) may be interpreted as having five or six sides. Martin's specimens have dimensions similar to that from the Pontyfenni Formation, although the latter has relatively shorter processes.




**Figs 95, 97** *Stelliferidium* aff. *fimbrium* (Rasul 1974) Rasul 1979; Pontyfenni Formation; × 1200. Fig. 95A, B, high and low focus; MPK 4978, sample MPA 20092; slide 1, L34/3. Fig. 97, MPK 4936, sample MPA 20091; slide 1, V62/0.

**Fig. 96A, B** ?*Striatotheca mutua* Burmann 1970, high and low focus; MPK 4935, sample MPA 20099, Pontyfenni Formation; slide 1, M31/4, × 1200.

**Fig. 98** ?*Striatotheca rarirrugulata* (Cramer, Kanes, Diez & Christopher 1974) Eisenack, Cramer & Diez 1976; MPK 4937, sample MPA 20102, Pontyfenni Formation; slide 1, Q70/4, × 1200.

**Fig. 99** *Striatotheca* sp.; MPK 4938, sample MPA 20103, Cwm yr Abbey Member; slide 2, H67/0, × 1200.

### ? *Striatotheca rarirrugulata* (Cramer, Kanes, Diez & Christopher 1974) Eisenack, Cramer & Diez 1976
Fig. 98

?1974 *Rugulidium rarirrugulatum* Cramer, Kanes, Diez & Christopher: 61; pl. 25, figs 19, 21, 23; pl. 26, fig. 24.
?1976 *Striatotheca rarirrugulata* (Cramer, Kanes, Diez & Christopher) Eisenack, Cramer & Diez: 775–776.

MATERIAL. One damaged specimen.

OCCURRENCE. Pontyfenni Formation: MPA 20102.

DESCRIPTION. The vesicle is four-sided, broken and striate; there are 4–6 widely spaced striations across its width. Two processes, both broken, are present at two of the corners of the vesicle.

DIMENSIONS. Vesicle diameter 21 × 20 μm; process length more than 11 μm.

REMARKS. Although the specimen is too badly damaged for a positive identification, its size, shape and the nature of its striate ornament suggest it is most probably a specimen of *S. rarirrugulata*.

### *Striatotheca* sp.
Fig. 99

MATERIAL. One specimen.

OCCURRENCE. Cwm yr Abbey Member: MPA 20103.

DESCRIPTION. The vesicle is four sided, folded and closely and relatively coarsely striate; there are about two striations per μm across the width of the vesicle. Four processes, at the corners of the vesicle and lying in the same plane, are long and conical, tapering to an acuminate tip from a broad base. The striations extend a little way onto the base of each process but the process stems are smooth.

DIMENSIONS. Vesicle diameter: 22 × 14 μm.
Process length: 25 μm.
Process width (at base): 4 μm.

REMARKS. The specimen is distinguished from other species of *Striatotheca* by the combination of small size and relatively long, broad-based processes. *Striatotheca frequens* Burmann, 1970, and *S. principalis* Burmann, 1970, are both larger and have relatively short processes. *S. principalis parva* Burmann, 1970, is of similar size but also has relatively short processes.

## Genus *TIMOFEEVIA* Vanguestaine, 1978

TYPE SPECIES. *Timofeevia lancarae* (Cramer & Diez 1972) Vanguestaine 1978.

### *Timofeevia lancarae* (Cramer & Diez 1972) Vanguestaine 1978
Fig. 127

1972 *Multiplicisphaeridium lancarae* Cramer & Diez: 42; pl. 1, figs 1–4, 6, 8; text-fig. 1.
1978 *Timofeevia lancarae* (Cramer & Diez) Vanguestaine: 272.

MATERIAL. One specimen.

OCCURRENCE. Pontyfenni Formation: MPA 20099.

DESCRIPTION. The vesicle is subspherical and its surface is divided into a number of polygonal fields by dark folds or protuberances. Twenty-five processes are visible, situated at the angles of the polygonal fields. They have hollow, cylindrical stems and divide distally to the fourth order. The terminal branches are fine filaments which, in some cases, link adjacent processes.

DIMENSIONS. Vesicle diameter 32 × 28 μm; process length 12 μm.

REMARKS. The elaborate distal process terminations of *Timofeevia lancarae* are diagnostic. The species has been recorded from the early Middle Cambrian to earliest Tremadoc (?) in Spain (Cramer & Diez 1972; Fombella 1978), and from the Middle and Upper Cambrian of Random Island, eastern Newfoundland (Martin & Dean 1981). Its presence in the Pontyfenni Formation is probably on account of reworking from rocks of Cambrian or, less likely, Tremadoc age.

### Genus *UNCINISPHAERA* Wicander, 1974

TYPE SPECIES. *Uncinisphaera lappa* Wicander 1974.

REMARKS. A number of species recorded from the Arenig succession of south-west Wales have similar features and are tentatively referred to the genus *Uncinisphaera* Wicander, 1974. The diagnostic characteristics of *Uncinisphaera* are a granulate wall, spherical vesicle and ornamented processes: at least two of these features are present on each of the taxa considered here. It is possible that all the species described herein are related to each other, but unlikely that they are closely related to the Devonian species *Uncinisphaera lappa* Wicander 1974 and *U. acantha* Wicander & Wood 1981. *Uncinisphaera* is distinguished from *Stellechinatum* by its spherical or subspherical rather than polygonal vesicle.

### *Uncinisphaera* ? sp. A
Figs 100–101, 119–120

MATERIAL. Three specimens.

OCCURRENCE. Pontyfenni Formation: MPA 20099.

DESCRIPTION. The vesicle is large, subspherical and, although poorly preserved, appears to have a granulate wall. There are about 40–50 slender, acuminate, moderately flexible and slightly tapering processes. They are relatively short, their average length being about one quarter of the vesicle diameter, possibly solid and bear an ornament of short lateral hairs.

DIMENSIONS. Vesicle diameter range 33–48 μm, mean 40 μm; process length range 9–12 μm.

REMARKS. The apparently granulate wall and ornamented processes would justify assignment *Uncinisphaera*, but the determination is tentative because of poor preservation.

*U. lappa* is smaller and has fewer, stouter, more conical processes. *U. acantha* is smaller and has fewer, relatively long processes. For comparisons with other taxa see the remarks under the following species of *Uncinisphaera*.

### *Uncinisphaera* ? sp. B
Figs 102, 104, 121–122

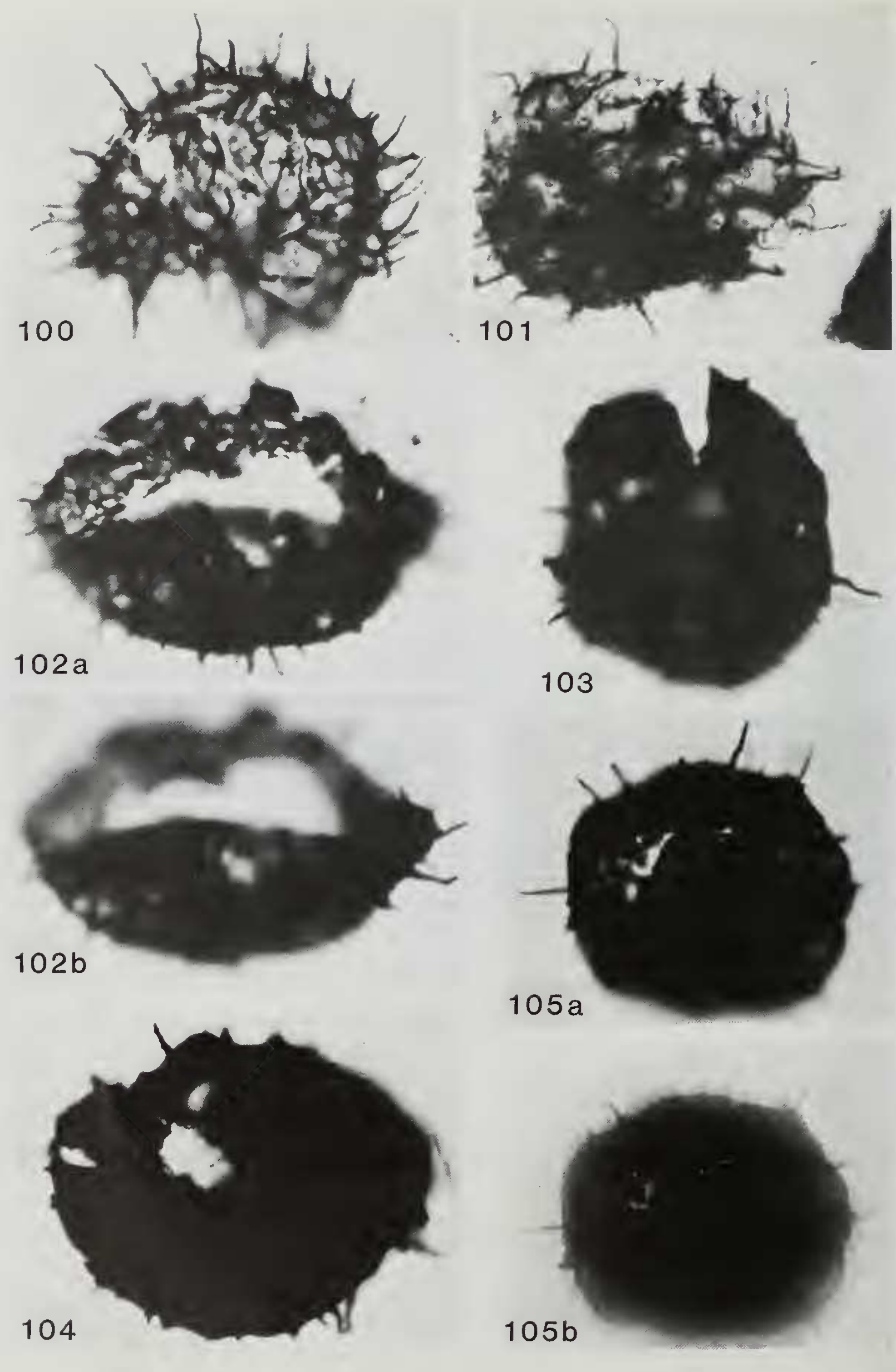
MATERIAL. Seven specimens.

OCCURRENCE. Pontyfenni Formation: MPA 20099.

DESCRIPTION. The vesicle is large and subspherical, with convex or concave sides between the process bases. There are about 50 relatively short, stiff or slightly flexible and evexate processes, which bear an ornament of short hairs; they average about one-ninth of the vesicle diameter in length.

DIMENSIONS. Vesicle diameter range 46–66 μm, mean 54 μm; process length range 5–10 μm, mean 6 μm.

REMARKS. *Uncinisphaera* ? sp. B is distinguished from *Uncinisphaera* ? sp. A by its larger size and shorter processes. The two taxa occur together in the Pontyfenni Formation, but no gradation occurs between them.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102b
105a
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105b

**Uncinisphaera** ? sp. C
Figs 103, 105, 123

MATERIAL. Nine specimens.

OCCURRENCE. Pontyfenni Formation: MPA 20091.

DESCRIPTION. The vesicle is subspherical with straight or convex sides. There are about 20 slender, simple, stiff, tapering and evexate processes, with an ornament of fine hairs or grana. One specimen apparently has an equatorial split.

DIMENSIONS. Vesicle diameter range 34–46 $\mu$m, mean 41 $\mu$m; process length range 4–10 $\mu$m, mean 8 $\mu$m.

REMARKS. *Uncinisphaera* ? sp. A has longer processes and a more prominent ornament. *Uncinisphaera* ? sp. B is larger and also has a more prominent ornament on the processes. *U. lappa* and *U. acantha* have smaller vesicles. For other comparisons see the remarks under *Uncinisphaera* ? sp. D.

**Uncinisphaera** ? sp. D
Figs 106–109, 124

MATERIAL. Nine specimens.

OCCURRENCE. Cwmffrŵd Member: MPA 20077, MPA 20087(?). Allt Cystanog Member: MPA 20074(?).

DESCRIPTION. The vesicle is large and subspherical with convex sides. The few, short, slender processes are relatively stiff, tapering and evexate. The number of processes is variable, between seven and seventeen; the lower number may reflect poor preservation.

DIMENSIONS. Vesicle diameter range 39–44 $\mu$m, mean 41 $\mu$m; process length range 5–8 $\mu$m, mean 6 $\mu$m.

REMARKS. *Uncinisphaera* ? sp. D is very similar to *Uncinisphaera* ? sp. C, but may be distinguished by its fewer, shorter processes. The differences are very slight, however, and it is possible that the two forms are conspecific. One specimen from the Allt Cystanog Member has shorter processes than the specimens of *Uncinisphaera* ? sp. D from the Cwmffrŵd Member, but is otherwise similar. The presence of the species in the upper part of the Cwmffrŵd Member (MPA 20087) is questionable because it is based on the occurrence of a few, poorly preserved specimens.

**Uncinisphaera** ? sp. E
Figs 110–111, 125

MATERIAL. Two specimens.

OCCURRENCE. Cwmffrŵd Member: MPA 20077.

DESCRIPTION. The vesicle is subspherical to subpolygonal. The processes are relatively short, conical and acuminate, and bear short lateral hairs. About 30 processes, about one third of the vesicle diameter in length, are present.

DIMENSIONS. Vesicle diameter range 30–32 $\mu$m, mean 30·5 $\mu$m; process length 8–10 $\mu$m.

REMARKS. *Uncinisphaera* ? sp. A is larger and has more numerous and more slender processes.

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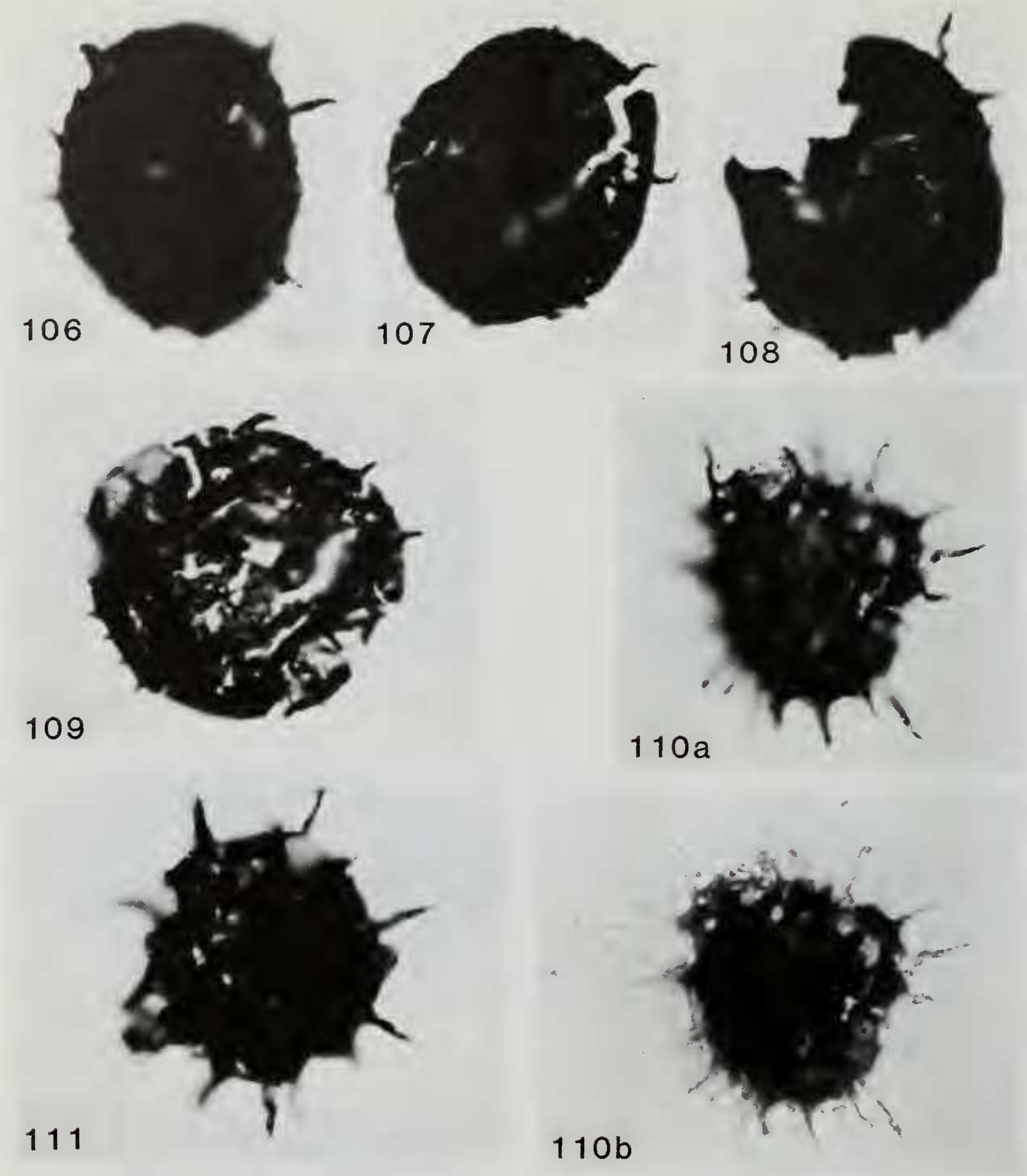
**Figs 100, 101** *Uncinisphaera*? sp. A; sample MPA 20099, Pontyfenni Formation; × 1200. Fig. 100, MPK 4939; slide 1, M31/2. See Fig. 119. Fig. 101, MPK 4940; slide 1, N38/0. See Fig. 120.

**Figs 102, 104** *Uncinisphaera*? sp. B; sample MPA 20099, Pontyfenni Formation; × 1200. Fig. 102A, B, MPK 4941; slide 1, M24/0. See Fig. 122. Fig. 104, MPK 4943, slide 1, R27/0. See Fig. 121.

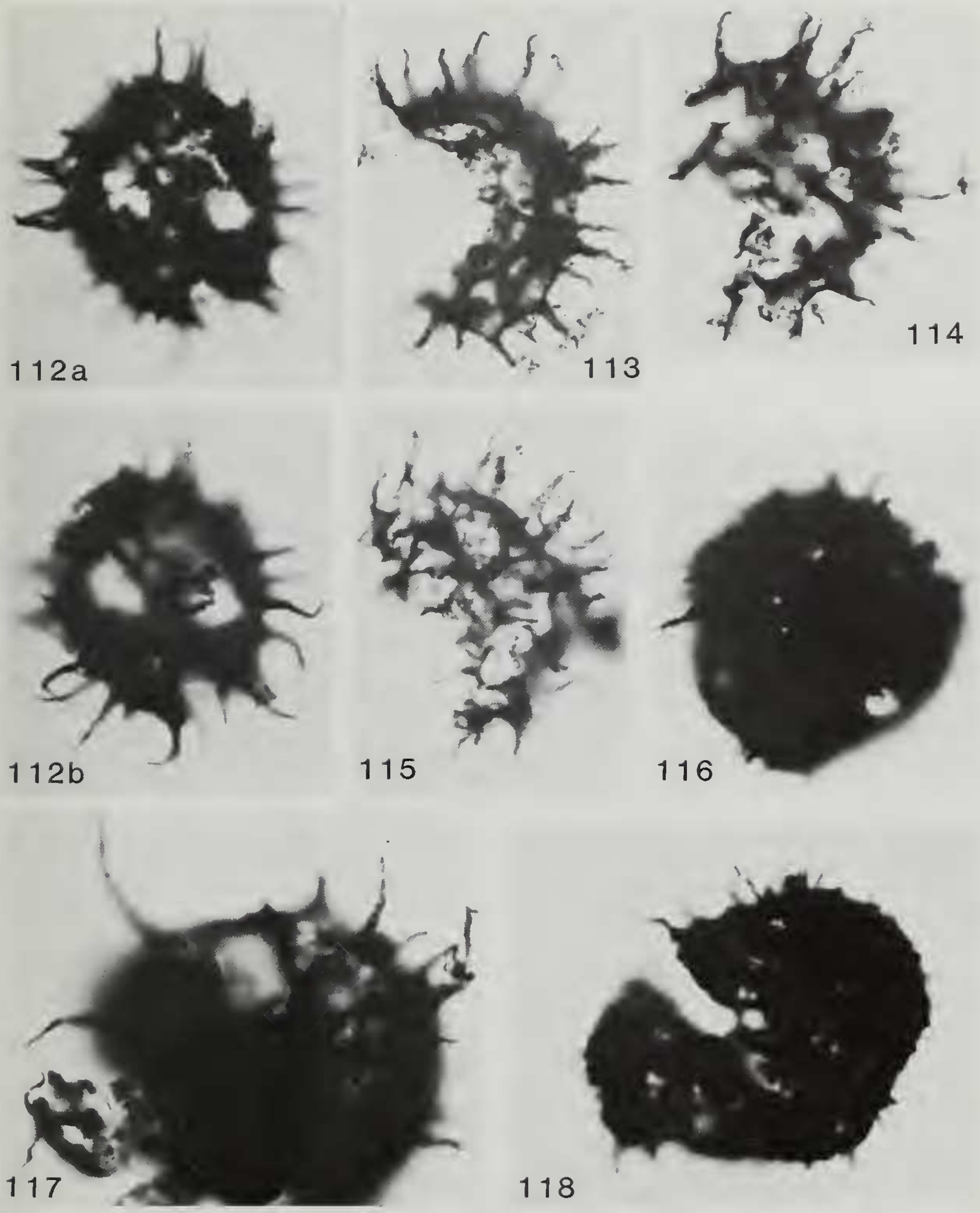
**Figs 103, 105** *Uncinisphaera*? sp. C; sample MPA 20091, Pontyfenni Formation; × 1200. Fig. 103, MPK 4942; slide 1, X42/1. Fig. 105A, B (B phase contrast), MPK 4944; slide 1, Q43/0. See Fig. 123.




**Figs 106–108** *Uncinisphaera*? sp. D; sample MPA 20077, Cwmffrŵd Member; × 1200. Fig. 106, MPK 4945; slide 2, M32/1. See Fig. 124. Fig. 107, MPK 4946; slide 2, R38/3. Fig. 108, MPK 4947; slide 2, L25/1.

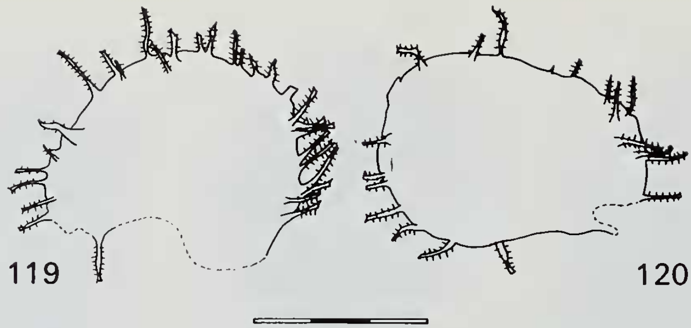
**Fig. 109** cf. *Uncinisphaera*? sp. D; MPK 4948, sample MPA 20074, Allt Cystanog Member; slide 1, F22/0, × 1200.

**Figs 110–111** *Uncinisphaera*? sp. E; sample MPA 20077, Cwmffrŵd Member; × 1200. Fig. 110A, B (B phase contrast), MPK 4949; slide 2, J42/0. See Fig. 125. Fig. 111, MPK 4950; slide 2, P29/1.




**Figs 112–115** *Uncinisphaera*? sp. F; sample MPA 20103, Cwm yr Abbey Member; × 1200. Fig. 112A, B, high and low focus, MPK 4951; slide 2, G21/2. See Fig. 126. Fig. 113, MPK 4952; slide 2, J56/0. Fig. 114, MPK 4953; slide 2, J58/4. Fig. 115, MPK 4954; slide 2, S64/0.

**Figs 116–118** *Uncinisphaera*? spp.; Cwm yr Abbey Member; × 1200. Fig. 116, MPK 4955, sample MPA 20084; slide 2, K44/0. Fig. 117, MPK 4956, sample MPA 20103; slide 1, E33/0. Fig. 118, MPK 4957, sample MPA 20084; slide 2, G35/3.



**Figs 119–120** *Uncinisphaera*? sp. A. Bar represents 30 $\mu$m. Fig. 119, MPK 4939. See Fig. 100. Fig. 120, MPK 4940. See Fig. 101.

### *Uncinisphaera* ? sp. F
Figs 112–115, 126

MATERIAL. Four specimens.

OCCURRENCE. Cwm yr Abbey Member: MPA 20103.

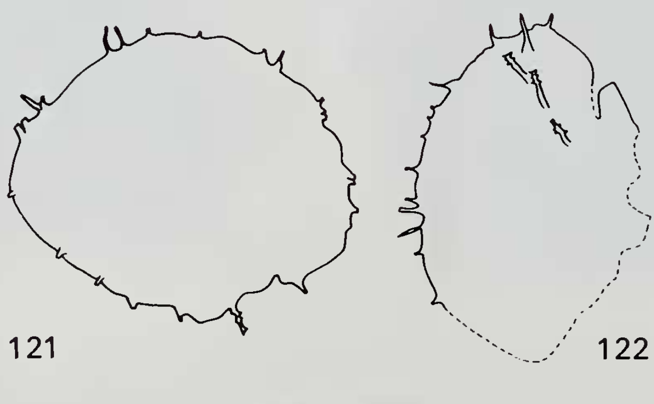
DESCRIPTION. The vesicle is subspherical and its sides are either masked by the process bases or concave. About 30 conical, relatively short, acuminate and granulate processes, with an average length of one quarter of the vesicle diameter, are present.

DIMENSIONS. Vesicle diameter range 28–35 $\mu$m, mean 33 $\mu$m; process length *c.* 8 $\mu$m.

REMARKS. Preservation is generally poor and three out of the four specimens are broken. The species may be readily distinguished by its broad conical processes which tend to mask the vesicle sides.

### *Uncinisphaera* ? spp.
Figs 116–118

REMARKS. Three poorly preserved specimens from the Cwm yr Abbey Member are included in the genus.



**Figs 121–122** *Uncinisphaera*? sp. B. Bar represents 30 $\mu$m. Fig. 121, MPK 4943. See Fig. 104. Fig. 122, MPK 4941. See Fig. 102.

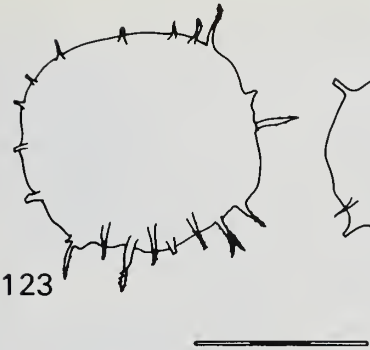


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**Fig. 123** *Uncinisphaera*? sp. C; MPK 4944. Bar represents 30 $\mu$m. See Fig. 105.
**Fig. 124** *Uncinisphaera*? sp. D; MPK 4945. Bar represents 30 $\mu$m. See Fig. 106.

Two specimens from MPA 20084 have subspherical vesicles with straight or convex sides. The processes, numbering 30–40, are relatively short, slender and moderately flexible, and bear a sparse ornament of fine hairs. The vesicle diameters are 38 × 39 $\mu$m (Fig. 116) and 48 × 37 $\mu$m (Fig. 118), and the average process length is 6 $\mu$m. The specimens may represent the same species but this cannot be confirmed because of their poor preservation.

One specimen (Fig. 117), from MPA 20103, has a large subspherical vesicle with straight or convex sides and a granulate surface. The processes, of which there are at least 21, are long, stout and moderately flexible, and are covered in relatively long hairs; their distal terminations are evexate or consist of two short, recurved hairs. The vesicle diameter is about 50 $\mu$m, and process length 16 $\mu$m.

### Genus *VERYHACHIUM* Deunff 1954 *ex* Downie 1959

TYPE SPECIES. *Veryhachium trisulcum* (Deunff 1951) Deunff 1959 *ex* Downie 1959.

#### '*Veryhachium trispinosum*' group
Figs 129, 131, 133

REMARKS. Three-spined species of *Veryhachium* are recorded from the Cwmffrŵd Member of the Carmarthen Formation and throughout the succeeding part of the Arenig Series (Fig. 5, p. 318). They are most common in the Fennian.

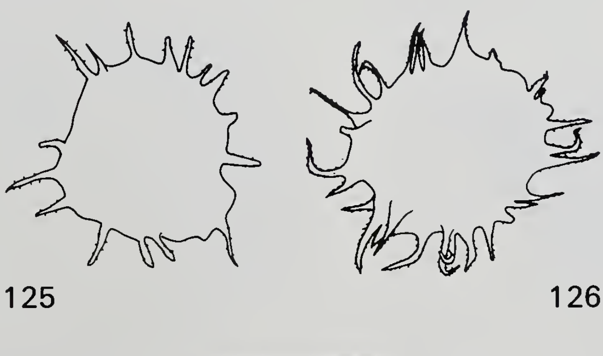

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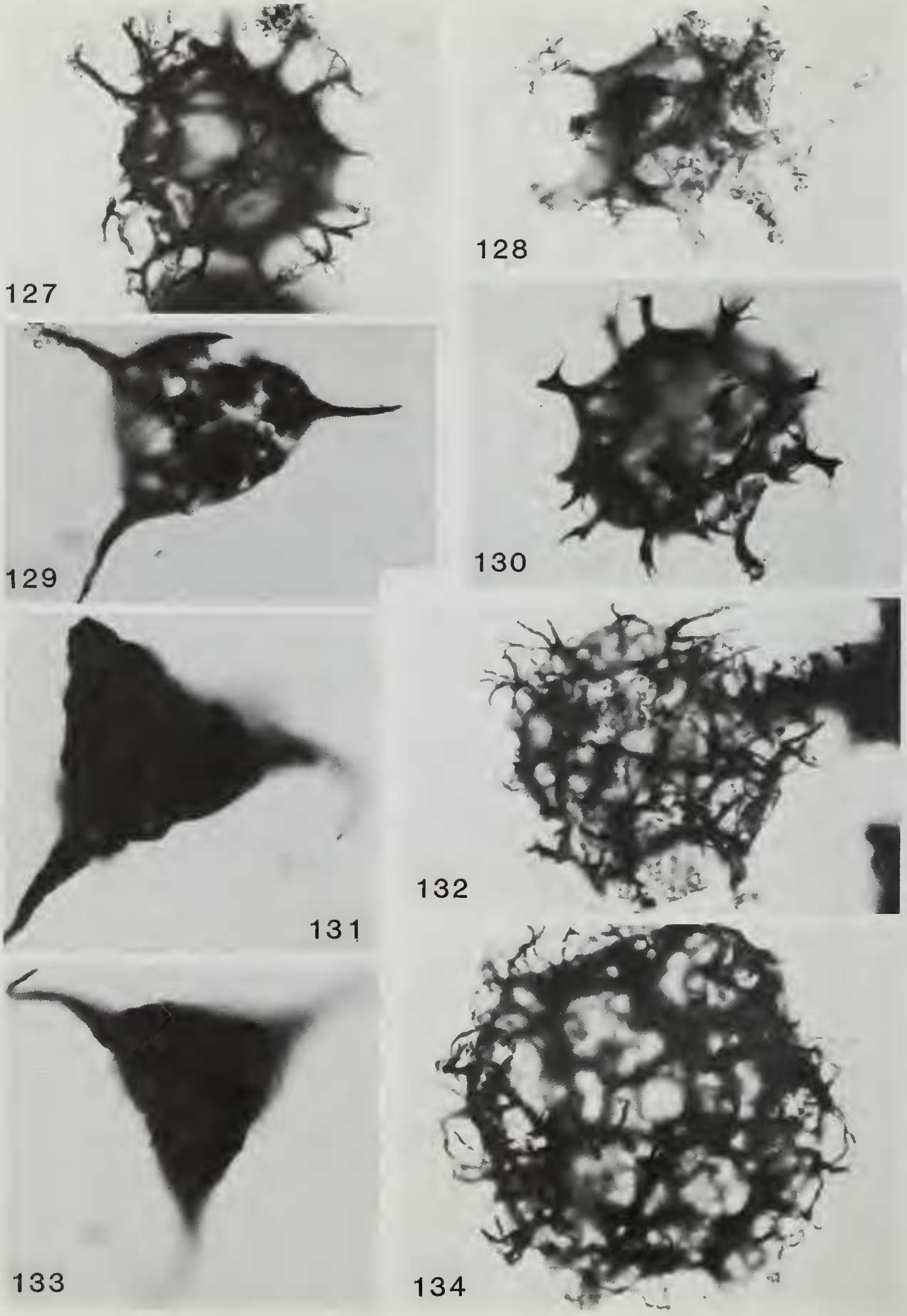
**Fig. 125** *Uncinisphaera*? sp. E; MPK 4949. Bar represents 30 $\mu$m. See Fig. 110.
**Fig. 126** *Uncinisphaera*? sp. F; MPK 4951. Bar represents 30 $\mu$m. See Fig. 112.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## Genus *VOGTLANDIA* Burmann, 1970

Type species. *Vogtlandia ramificata* Burmann 1970.

### ?*Vogtlandia flosmaris* (Deunff 1977) Dean & Martin 1978
Fig. 128

?1977 *Evittia flosmaris* Deunff: 143; pl. 1, fig. 18; pl. 2, figs 7, 9, 11, 14.
?1978 *Vogtlandia coalita* Dean & Martin: 9–10; pl. 2, figs 3, 7.
?1978 *Vogtlandia flosmaris* (Deunff) Dean & Martin: 19.
?1982 *Vogtlandia flosmaris* (Deunff) Dean & Martin: Martin; pl. 1, fig. 3.

Material. One specimen.

Occurrence. Allt Cystanog Member: MPA 20074.

Description. The vesicle is subpolygonal in outline but the vesicle sides are masked to some extent by the wide process bases. The processes, of which there are 12, have stout stems and divide distally to the fourth order, terminating in long, slender filaments.

Dimensions. Vesicle diameter: 24 $\mu$m × 24 $\mu$m.
Process length (overall): 14 $\mu$m.
Process length from proximal contact to first bifurcation: 8 $\mu$m.
Process length from first bifurcation to distal termination: 6 $\mu$m.

Remarks. The specimen has relatively long distal filaments like those on the specimens illustrated by Deunff (1977) and Martin (1982), but there is no evidence they are intertwined (cf. Dean & Martin 1978: 10; pl. 2, figs 3, 7). This difference might be explained by the poor preservation of the specimen from the Allt Cystanog Member.

## Genus *VULCANISPHAERA* Deunff, 1961

Type species. *Vulcanisphaera africana* Deunff 1961.

### *Vulcanisphaera britannica* Rasul 1976
Fig. 130

1976 *Vulanisphaera britannica* Rasul: 482–484; pl. 1, figs 2, 7–9, 13–16; text-fig. 1: 4, 5.

Material. One specimen.

Occurrence. Pontyfenni Formation: MPA 20099.

Description. The vesicle is subpolygonal and bears at least twenty processes, which have stout stems dividing distally into three or four branches. All the branches arise from a common point and are acuminate and possibly acicular.

Dimensions. Vesicle diameter 32 × 28 $\mu$m; process length *c.* 12 $\mu$m.

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**Fig. 127** *Timofeevia lancarae* (Cramer & Diez 1972) Vanguestaine 1978; MPK 4958, sample MPA 20099, Pontyfenni Formation; slide 1, N34/4, × 1200.

**Figs 129, 131, 133** '*Veryhachium trispinosum*' group; × 1200. Fig. 129, MPK 4960, sample MPA 20103, Cwm yr Abbey Member; slide 2, D74/4. Figs 131, 133, sample MPA 20091, Pontyfenni Formation. Fig. 131, MPK 4962; slide 1, U29/2. Fig. 133, MPK 4964; slide 1, O46/0.

**Fig. 128** ?*Vogtlandia flosmaris* (Deunff 1977) Dean & Martin 1978; MPK 4959, sample MPA 20074, Allt Cystanog Member; slide 2, K51/4, × 1200.

**Fig. 130** *Vulcanisphaera britannica* Rasul 1976; MPK 4961, sample MPA 20099, Pontyfenni Formation; slide 1, G26/2, × 1200.

**Figs 132, 134** *Vulcanisphaera turbata*? Martin *in* Martin & Dean 1981; × 1200. Fig. 132, MPK 4963, sample MPA 20099, Pontyfenni Formation; slide 1, L37/3. Fig. 134, MPK 4965, sample MPA 20103, Cwm yr Abbey Member; slide 1, L38/2.

REMARKS. The specimen is most like *Vulcanisphaera britannica, forma* 2 of Rasul (1976), recorded from the Shineton Shales (of Tremadoc age), Shropshire. It indicates probable reworking of Tremadoc forms into the lower part of the Pontyfenni Formation.

***Vulcanisphaera turbata*?** Martin 1981
Figs 132, 134

?1981 *Vulcanisphaera turbata* Martin *in* Martin & Dean: 23–24; pl. 1, figs 2–4; text-fig. 6.

MATERIAL. Two specimens.

OCCURRENCE. Cwm yr Abbey Member: MPA 20103. Pontyfenni Formation: MPA 20099.

DESCRIPTION. The vesicle is subspherical. The processes are rarely single, more usually grouped into clusters of two, three or four. Filamentous threads arise laterally from some of the processes. A number of polygonal fields are delimited by dark folds or protuberances on the surface of the vesicle.

DIMENSIONS. Vesicle diameters 40 × 36 μm and 48 × 45 μm; process length 8 × 10 μm.

REMARKS. The specimens resemble *V. turbata*, and also show some similarity to *Vulcanisphaera cirrita* Rasul, 1976, and *V. africana* Deunff, 1961, as understood by Martin (*in* Martin & Dean, 1981). The determination is tentative on account of poor preservation. *V. turbata* was described from late Middle Cambrian and Upper Cambrian rocks of Random Island, eastern Newfoundland, and its presence may indicate the possible reworking of Cambrian forms into the Arenig Series of south-west Wales.

## Systematic descriptions: Chitinozoa

The descriptive terminology used in this section is that of Laufeld (1974). The general remarks on p. 319–20 apply here also.

Genus ***BELONECHITINA*** Jansonius, 1964

TYPE SPECIES. *Conochitina micracantha robusta* Eisenack 1959.

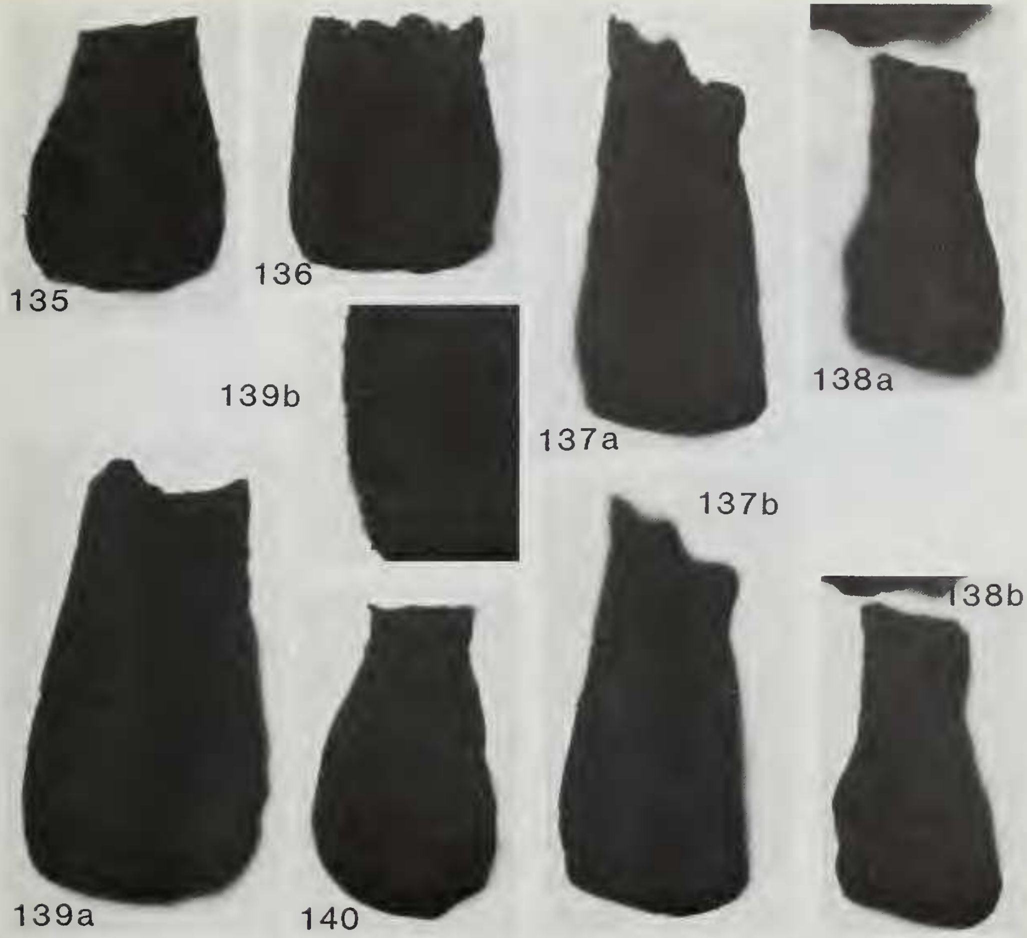
***Belonechitina*** spp.
Figs 135–137, 139

Eight specimens from the Pontyfenni Formation (MPA 20091) are assigned to this genus. There are two distinct forms, distinguished by size, but it is possible that they represent a single species.

DESCRIPTIONS. Four specimens have cylindro-conical vesicles which are poorly divided into a chamber and a neck by weakly-developed flexures and shoulders. The chamber is subconical, the basal edge rounded and the base flat to slightly convex. The neck is cylindrical and slightly narrower than the chamber. The vesicle bears an ornament of short hairs and grana which are most prominent on the basal edge. Dimensions of the four specimens are as follows: vesicle length 76–84 μm, mean 81 μm; chamber width 61–72 μm, mean 66 μm; neck width 34–53 μm, mean 44 μm. (See Figs 137, 139).

The other four specimens also have cylindro-conical vesicles, but the neck is not differentiated from the chamber, or is only poorly differentiated by a weakly-developed flexure. The basal edge is rounded and the base is flat or concave. The neck of all four specimens is broken orally. An ornament of fine hairs is present on the vesicle. Dimensions of these specimens are: vesicle length 118–152 μm, mean 133 μm; chamber width 57–74 μm, mean 65 μm; neck width 29–48 μm, mean 34 μm. (See Figs 135, 136).

REMARKS. *Belonechitina henryi* Paris 1981 has a longer vesicle than either form from the Pontyfenni Formation. *B. micracantha typica* (Eisenack 1965) has similar dimensions, is variable in shape and has an ornament well developed on the basal edge but not on the flanks. All the specimens from the Pontyfenni Formation resemble *B. micracantha typica*, but the ornament may be more widely distributed over the vesicle surface than in that species.




**Figs 135–137, 139** *Belonechitina* spp.; Pontyfenni Formation; × 480 (Fig. 139B × 1200). Fig. 135, MPK 4966, sample MPA 20092; slide 2, L21/0. Fig. 136, MPK 4967, sample MPA 20091; slide 1, K22/4. Fig. 137A, B, high and low focus, MPK 4968, sample MPA 20091; slide 2, H25/3. Fig. 139A, B (B detail of surface ornament × 1200), MPK 4970, sample MPA 20092; slide 2, J22/1.

**Fig. 138A, B** *Lagenochitina cylindrica*? Eisenack 1931, high and low focus; MPK 4969, sample MPA 20091, Pontyfenni Formation; slide 1, U25/3, × 480.

**Fig. 140** *Conochitina* cf. *chydaea* Jenkins 1967; MPK 4971, sample MPA 20092, Pontyfenni Formation; slide 1, P19/0, × 1200.

## Genus *CONOCHITINA* Eisenack, 1931

TYPE SPECIES. *Conochitina claviformis* Eisenack 1931.

### ***Conochitina* cf. *chydaea* Jenkins 1967**
Fig. 140

cf. 1967 *Conochitina chydaea* Jenkins: 453–454; pl. 70, figs 4–8.

MATERIAL. Six specimens.

OCCURRENCE. Pontyfenni Formation: MPA 20091.

DESCRIPTION. The vesicle is cylindro-conical, the base flat or slightly convex and the basal edge rounded. Flexures and shoulders are not developed. The neck is poorly developed and may flare aborally of the aperture.

DIMENSIONS. Vesicle length: range 93–148 μm; mean 111 μm.
Width (chamber): range 44–57 μm; mean 53 μm.
Width (neck): range 30–38 μm; mean 35 μm.
Width (aperture): range 23–42 μm: mean 33 μm.

REMARKS. *Conochitina chydaea* is variable in morphology. The specimens recorded from the Pontyfenni Formation bear some resemblance to the type material (Jenkins 1967) from the Llanvirn of Shropshire, but are smaller.

## Genus ***LAGENOCHITINA*** Eisenack, 1931

TYPE SPECIES. *Lagenochitina baltica* Eisenack 1931.

### ***Lagenochitina cylindrica*?** Eisenack 1931
Fig. 138A, B

?1931 *Lagenochitina cylindrica* Eisenack: 81; pl. 2, figs 18, 19.
?1967 *Lagenochitina cylindrica* Eisenack; Jenkins: 463; pl. 74, figs 1–3.

MATERIAL. One specimen.

OCCURRENCE. Pontyfenni Formation: MPA 20091.

DESCRIPTION. The vesicle has a conspicuous flexure and shoulder that differentiate the chamber from the neck. The chamber is subcylindrical with a flat base and a rounded basal edge. The neck is cylindrical.

DIMENSIONS. Vesicle length 112 μm; length of chamber 65 μm; length of neck 48 μm; width of chamber 48 μm; width of neck 36 μm.

REMARKS. The specimen is small for *Lagenochitina cylindrica* but resembles those illustrated by Jenkins (1967) from the Llanvirn of Shropshire.

### ***Lagenochitina*** sp. A
Figs 141–143

MATERIAL. Thirty specimens.

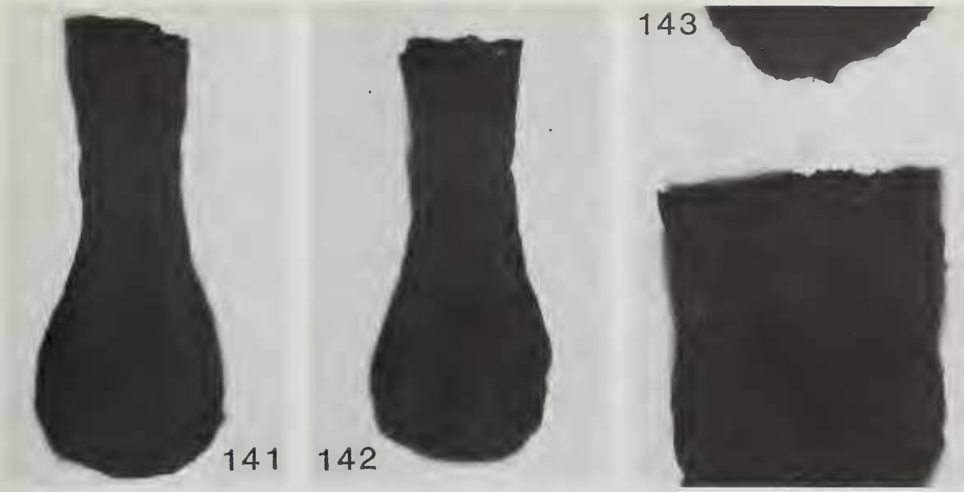
OCCURRENCE. Pontyfenni Formation: MPA 20091–3.

DESCRIPTION. The chamber is subcylindrical to subconical and rarely sphaeroidal. The flexure is usually more conspicuous than the shoulder, the latter being broadly rounded. The basal edge may or may not be present; when present it is convex and rounded to broadly rounded. The base is flat or convex. The neck is long and cylindrical, widening slightly near the aperture. The length of the neck is usually a little over half the total length of the vesicle. The aperture is fringed by short spines but the vesicle is otherwise smooth.

DIMENSIONS. Vesicle length: range 110–162 μm; mean 141 μm.
Length of neck: range 53–99 μm; mean 76 μm.
Length of chamber: range 49–84 μm; mean 66 μm.
Width of neck: range 29–42 μm; mean 36 μm.
Width of chamber: range 44–68 μm; mean 59 μm.
Width of aperture: range 29–42 μm; mean 38 μm.

REMARKS. *Lagenochitina* sp. A is the most commonly occurring chitinozoan in the Pontyfenni Formation near Maesyrwyn. It is unlike other species of *Lagenochitina*, being distinguished by its relatively long neck, fringed aperture and the shape of its chamber.

*Lagenochitina obeligis* Paris 1981 is larger, has a relatively shorter neck, an ovoidal chamber and a more convex base, and its aperture is not fringed. *L. esthonica* Eisenack 1955 has a very characteristic shape that distinguishes it from the present *Lagenochitina* sp. A. *L. shelvensis*




**Figs 141–143** *Lagenochitina* sp. A; Pontyfenni Formation; × 480 (Fig. 143 × 1200). Fig. 141, MPK 4976, sample MPA 20091; slide 2, T31/2. Fig. 142, MPK 4975, sample MPA 20092; slide 1, P40/3. Fig. 143, detail of aperture × 1200, MPK 4974, sample MPA 20091; slide 2, G32/3.

Jenkins 1967 and *Lagenochitina* sp. of Achab (1982) are both larger than the present form, and both have relatively shorter necks. Achab's *Lagenochitina* sp. also has a more or less quadrangular chamber.

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## Sample localities

1. *Ogof Hên Formation*: Allt Cystanog Member.
   MPA 20074. 140 m at 112° from Star Cottage (SN 4305 1979). Loc. 4b of Owens & Fortey (1982).
2. *Ogof Hên Formation*: Bolahaul Member.
   MPA 20075–6. 10 m at 227° from Star Cottage (SN 4291 1981). Loc. 8 Fortey & Owens (1978).
   MPA 20079. Roman Road, Pensarn. 105 m at 140° from chapel at Pensarn (SN 4141 1911). Loc. 6 of Fortey & Owens (1978).
   MPA 20080. Roman Road, Pensarn. 80 m at 149° from chapel at Pensarn (SN 4137 1914). Loc. 6 of Fortey & Owens (1978).
3. *Carmarthen Formation*: Cwmffrŵd Member.
   MPA 20077–8. Nantycaws dingle. 410 m at 233° from Ty-cerig (SN 4510 1844). Loc. 7 of Owens & Fortey (1982).
   MPA 20086. Nant y Glasdwr. 50 m at 130° from Nant-y-Glasdwr-fâch (SN 4239 1756). Loc. 3E of Fortey & Owens (1978).
   MPA 20087. Nant y Glasdwr. 95 m at 131° from Nant-y-Glasdwr-fâch (SN 4242 1753). Loc. 3D of Fortey & Owens (1978).
4. *Carmarthen Formation*: Cwm yr Abbey Member.
   MPA 20081. Nant y Glasdwr. 40 m at 169° from Gwynion Dale (SN 4272 1748). Loc. 3A of Fortey & Owens (1978).
   MPA 20082. Nant y Glasdwr. 55 m at 218° from Gwynion Dale (SN 4267 1748). Loc. 3A of Fortey & Owens (1978).
   MPA 20083. Nant y Glasdwr. 75 m at 228° from Gwynion Dale (SN 4265 1747). Loc. 3A of Fortey & Owens (1978).

MPA 20084. Nant y Glasdwr. 100 m at 235° from Gwynion Dale (SN 4263 1746). Loc. 3A of Fortey & Owens (1978).
MPA 20085. Nant y Glasdwr. 120 m at 238° from Gwynion Dale (SN 4261 1746). Loc. 3A of Fortey & Owens (1978).
MPA 20088. Nant y Glasdwr. 160 m at 252° from Gwynion Dale (SN 4256 1747). Near loc. 3B of Fortey & Owens (1978).
MPA 20089. Nant y Glasdwr. 165 m at 251° from Gwynion Dale (SN 4255 1747). Near loc. 3B of Fortey & Owens (1978).
MPA 20090. Nant y Glasdwr. 185 m at 257° from Gwynion Dale (SN 4253 1748). Near loc. 3B of Fortey & Owens (1978).
MPA 20103. Cwm yr Abbey. 400 m at 322° from Abbey Farm (SN 5002 1978). Loc. 16 of Fortey & Owens (1978).

5. *Afon Ffinnant Formation.*
MPA 20104–5. Cwm yr Abbey. 400 m at 322° from Abbey Farm (SN 5001 1979). Loc. 16 of Fortey & Owens (1978, 1987).

6. *Colomendy Formation*: Whitland Abbey Member.
MPA 20094. 340 m at 290° from Whitland Abbey (SN 2060 1822). Near loc. 27 of Fortey & Owens (1987).
MPA 20095. 210 m at 287° from Whitland Abbey (SN 2072 1818). Near loc. 27 of Fortey & Owens (1987).
MPA 20096. 210 m at 285° from Whitland Abbey (SN 2072 1818). Near loc. 27 of Fortey & Owens (1987).
MPA 20097. 210 m at 284° from Whitland Abbey (SN 2072 1817). Near loc. 27 of Fortey & Owens (1987).
MPA 20098. 200 m at 278° from Whitland Abbey (SN 2072 1815). Near loc. 27 of Fortey & Owens (1987).

7. *Pontyfenni Formation.*
MPA 20091. 560 m at 260° from Maesyrwyn (SN 2379 1694). Loc. 23 of Fortey & Owens (1987).
MPA 20092. 540 m at 262° from Maesyrwyn (SN 2381 1696). Loc. 23 of Fortey & Owens (1987).
MPA 20093. 520 m at 264° from Maesyrwyn (SN 2383 1699). Loc. 23 of Fortey & Owens (1987).
MPA 20099–100. 400 m at 353° from Penlan (SN 1984 1948). Loc. 38 of Fortey & Owens (1987).
MPA 20101–2. 400 m at 356° from Penlan (SN 1986 1949). Loc. 38 of Fortey & Owens (1987).

## References

**Achab, A.** 1982. Chitinozoaires de l'Arenig supérieur (Zone D) de la Formation de Lévis, Québec, Canada. *Can. J. Earth Sci.*, Ottawa, **19** (6): 1295–1307.

**Arthurton, R. S. & Wadge, A. J.** 1981. Geology of the country around Penrith. *Mem. Geol. Surv. G. B.*, London, Sheet **24**. 177 pp.

**Babin, C., Arnaud, A., Blaise, J., Cavet, P., Chauvel, J. J., Deunff, J., Henry, J.-L., Lardeux, H., Mélou, M., Nion, J., Paris, F., Quété, Y. & Robardet, M.** 1976. The Ordovician of the Armorican Massif (France). *In* Bassett, M. G. (ed.), *The Ordovician System: proceedings of a Palaeontological Association symposium, Birmingham, September 1974*: 359–385. Cardiff, Univ. Wales & Natl Mus. Wales.

**Benoit, A. & Taugourdeau, P.** 1961. Sur quelques chitinozoaires de l'Ordovicien du Sahara. *Revue Inst. fr. Pétrole*, Paris, **26**: 1403–1421.

**Bockelie, T. G.** 1980. Early Ordovician chitinozoa from Spitsbergen. *Palynol.*, Dallas, **4**: 1–14.

**Booth, G. A.** (1979). *Lower Ordovician acritarchs from successions in England and North Wales*. Ph.D. thesis, Univ. Sheffield (unpubl.).

**Burmann, G.** 1970. Weitere organische Mikrofossilien aus dem unteren Ordovizium. *Paläont. Abh. Berl.*, (B) **3**: 289–325.

**Cocks, L. R. M. & Fortey, R. A.** 1982. Faunal evidence for oceanic separations in the Palaeozoic of Britain. *J. geol. Soc. Lond.*, **139**: 465–478.

**Combaz, A.** 1967. Un microbios du Trémadocien dans un sondage d'Hassi-Messaoud. *Act. Soc. linn. Bordeaux*, (B) **104** (29): 1–26.

—— **& Peniguel, G.** 1972. Étude palynostratigraphique de l'Ordovicien dans quelques sondages du Bassin de Canning (Australie occidentale). *Bull. Cent. Rech. Pau*, **6** (1): 121–167.

**Cooper, R. A. & Fortey, R. A.** 1982. The Ordovician graptolites of Spitsbergen. *Bull. Br. Mus. nat. Hist.*, London, (Geol.) **36** (3): 157–302, pls 1–6.

**Cramer, F. H.** 1970. Distribution of selected Silurian acritarchs. *Revta esp. Micropaleont.*, Madrid, **núm. extraord.** 203 pp., pls 1–23.

——, **Allam, B., Kanes, W. H. & Diez, M. del C. R.** 1974. Upper Arenigian to lower Llanvirnian acritarchs from the subsurface of the Tadla Basin in Morocco. *Palaeontographica*, Stuttgart, (B) **145:** 182–190.

—— **& Diez, M. del C. R.** 1972. Acritarchs from the Upper Middle Cambrian Oville Formation of León, northwestern Spain. *Revta esp Micropaleont*, Madrid, **núm. extraord.** (XXX Aniv. E. N. Adaro): 39–50.

—— —— 1976. Seven new late Arenigian species of the Acritarch Genus *Coryphidium* Vavrdova, 1972. *Paläont. Z.*, Stuttgart, **50:** 201–208.

—— —— 1977. Late Arenigian (Ordovician) acritarchs from Cis-Saharan Morocco. *Micropaleontology*, New York, **23** (3): 339–360.

——, **Kanes, W. H., Diez, M. del C. R. & Christopher, R. A.** 1974. Early Ordovician acritarchs from the Tadla Basin of Morocco. *Palaeontographica*, Stuttgart, (B) **146:** 57–64.

**Dean, W. T. & Martin, F.** 1978. Lower Ordovician acritarchs and trilobites from Bell Island, eastern Newfoundland. *Bull. geol. Surv. Can.*, Ottawa, **284.** 35 pp., 7 pls.

**Deflandre, G.** 1937. Microfossiles des silex crétacés. II. Flagellés *incertae sedis.* Hystrichosphaeridés. Sarcodinés. Organismes divers. *Annls Paléont.*, Paris, **26:** 51–103 (3–55), pls 8–15 (11–18).

—— 1938. Microplancton des mers jurassiques conservé dans les marnes de Villers-sur-Mer (Calvados). Étude preliminaire et considérations générales. *Trav. Stn zool. Wimereux*, Paris, **13:** 147–211, pls 5–11.

—— 1942. Sur les Hystrichosphères des calcaires Siluriens de la Montagne Noire. *C. r. hebd. Séanc. Acad. Sci.*, Paris, **215:** 475–476.

—— 1945. Microfossiles des calcaires Siluriens de la Montagne Noire. *Annls Paléont.*, Paris, **31:** 41–75.

—— **& Deflandre-Rigaud, M.** 1962. Nomenclature et systématiques des Hystrichosphères (sens. lat.). Observations et rectifications. *Revue Micropaléont.*, Paris, **4:** 190–196.

**Deunff, J.** 1951. Sur la présence de microorganismes (Hystrichosphères) dans les schistes ordoviciens du Finistère. *C. r. hebd. Séanc. Acad. Sci.*, Paris, **233:** 321–323.

—— 1954. *Veryhachium*, genre nouveau d'Hystrichosphères du Primaire. *C. r. somm. Séanc. Soc. géol. Fr.*, Paris, **13:** 305–307.

—— 1959. Microorganismes planctoniques du Primaire armoricain. I. Ordovicien du Veryhac'h (Presqu'île de Crozon). *Bull. Soc. géol. miner. Bretagne*, Rennes, (n.s.) **1958** (2): 1–41.

—— 1961. Un microplancton à Hystrichosphères dans le Trémadoc du Sahara. *Revue Micropaléont.*, Paris, **4:** 37–52, pls 1–3.

—— 1964. Systématique du microplancton fossile à acritarches. Révision de deux genres de l'Ordovicien inférieur. *Revue Micropaléont.*, Paris, **7:** 119–124.

—— 1977. Un microplancton à acritarches dans les schistes llanvirniens de l'anti-Atlas (Zagore–Maroc). *Notes Mém. Serv. Mines Carte géol. Maroc*, Rabat, **38** (268): 141–151.

——, **Gorka, H. & Rauscher, R.** 1974. Observations nouvelles et précisions sur les acritarches à large ouverture polaire du Paleozoïque inférieur. *Géobios*, Lyon, **7:** 5–18.

**Dhonau, T. J.** 1982. *Notes for Authors.* iv + 35 pp. London, Institute of Geological Sciences.

**Downie, C.** 1958. An assemblage of microplankton from the Shineton Shales (Tremadocian). *Proc. Yorks. geol. Soc.*, Hull, **31:** 331–350.

—— 1959. Hystrichospheres from the Silurian Wenlock Shale of England. *Palaeontology*, London, **2:** 56–71.

—— **& Sarjeant, W. A. S.** 1965. Bibliography and index of fossil dinoflagellates and acritarchs. *Mem. geol. Soc. Am.*, Washington, **94:** 1–180.

**Eisenack, A.** 1931. Neue Mikrofossilien des baltischen Silurs I. *Paläont. Z.*, Berlin, **13:** 74–118.

—— 1955. Neue Chitinozoen aus dem Silur des Baltikums und dem Devon der Eifel. *Senckenberg. leth.*, Frankfurt a.M., **36:** 311–319.

—— 1959. Neotypen baltischer Silur – Chitinozoen und neue Arten. *Neues Jb. Geol. Paläont. Abh.*, Stuttgart, **108:** 1–20.

—— 1963. Mitteilungen zur Biologie der Hystrichosphären und über neue Arten. *Neues Jb. Geol. Paläont. Abh.*, Stuttgart, **118:** 207–216.

—— 1965. Die Mikrofauna der Ostseekalke. I. Chitinozoen, Hystrichosphären. *Neues Jb. Geol. Paläont. Abh.*, Stuttgart, **123:** 115–148.

—— 1968. Mikrofossilien eines Geschiebes der Borkholmer Stufe, baltisches Ordovizium $F_2$. *Mitt. geol. StInst. Hamb.*, **37:** 81–94.

——, **Cramer, F. H. & Diez, M. del C. R.** 1976. *Katalog der fossilen Dinoflagellaten, Hystrichosphären und verwandten Mikrofossilien*, **4** (Acritarcha 2). xxiv + 863 pp. Stuttgart.

**Fombella, M. A.** 1978. Acritarcos de la Formación Oville, edad Cámbrico Medio–Tremadoc, Provincia de León, España. *Palinologia*, León, **núm. extraord. 1:** 245–261.

**Fortey, R. A. & Owens, R. M.** 1978. Early Ordovician (Arenig) stratigraphy and faunas of the Carmarthen district, south-west Wales. *Bull. Br. Mus. nat. Hist.*, London, (Geol.) **30** (3): 225–294, pls 1–11.

—— —— 1984. A synopsis of the Arenig Series in South Wales. *Proc. Geol. Ass.*, London, **95** (4): 389–390.

—— —— 1987. The Arenig Series in South Wales. *Bull. Br. Mus. nat. Hist.*, London, (Geol.) **41** (3): 69–307.

**Grahn, Y.** 1980. Early Ordovician chitinozoa from Öland. *Sver. geol. Unders. Afh.*, Uppsala, (C) **775:** 1–41.

**Jackson, D. E.** 1978. The Skiddaw Group. *In* Moseley, F. (ed.), *The Geology of the Lake District*: 79–98, pls 6–9. Leeds, Yorkshire Geol. Soc. (Occas. publ. 3).

**Jansonius, J.** 1964. Morphology and classification of some Chitinozoa. *Bull. Can. Petrol. Geol.*, Calgary, **12:** 901–918.

**Jenkins, W. A. M.** 1967. Ordovician Chitinozoa from Shropshire. *Palaeontology*, London, **10** (3): 436–488.

**Kjellström, G.** 1971. Middle Ordovician microplankton from the Grötlingbo Borehole No. 1 in Gotland, Sweden. *Sver. geol. Unders. Afh.*, Stockholm, (C) **669:** 1–35.

—— 1976. Lower Viruan (Middle Ordovician) microplankton from the Ekön Borehole No. 1 in Ostergotland, Sweden. *Sver. geol. Unders. Afh.*, Stockholm, (C) **724:** 1–43.

**Laufeld, S.** 1974. Silurian Chitinozoa from Gotland. *Fossils Strata*, Oslo, **5:** 1–130.

**Lister, T. R.** 1970. The acritarchs and chitinozoa from the Wenlock and Ludlow Series of the Ludlow and Millichope areas, Shropshire, (1): 1–100, pls 1–13. *Palaeontogr. Soc.* (*Monogr.*), London.

**Loeblich, A. R. & Tappan, H.** 1976. Some new and revised organic-walled phytoplankton microfossil genera. *J. Paleont.*, Tulsa, **50** (2): 301–308.

**Martin, F.** 1965. Les acritarches de Sart-Bernard (Ordovicien Belge). *Bull. Soc. belge Géol. Paléont. Hydrol.*, Brussels, **74:** 423–444.

—— 1969*a*. Chitinozoaires de l'Arenig supérieur–Llanvirn inférieur en Condroz (Belgique). *Revue Micropaléont.*, Paris, **12** (2): 99–106.

—— 1969*b* (for 1968). Les acritarches de l'Ordovicien et du Silurien belges. Determination et valeur stratigraphique. *Mém. Inst. r. Sci. nat. Belg.*, Brussels, **160:** 1–75.

—— 1972. Les acritarches de l'Ordovicien inférieur de la Montage Noire (Hérault, France). *Bull. Inst. r. Sci. nat. Belg.*, Brussels, (Sci. Terre) **48** (10): 1–61.

—— 1982. Some aspects of late Cambrian and early Ordovician acritarchs. *In* Bassett, M. G. & Dean, W. T. (eds), *The Cambrian–Ordovician boundary: sections, fossil distributions and correlations*: 29–40. Cardiff, Natl Mus. Wales (Geol. Ser. **3**).

—— **& Dean, W. T.** 1981. Middle and Upper Cambrian and Lower Ordovician acritarchs from Random Island, eastern Newfoundland. *Bull. geol. Surv. Can.*, Ottawa, **343:** 1–43.

**Molyneux, S. G.** 1979. New evidence for the age of the Manx Group, Isle of Man. *In* Harris, A. L., Holland, C. H. & Leake, B. E. (eds), The Caledonides of the British Isles—reviewed. *Spec. Publs geol. Soc. Lond.*, **8:** 415–421.

**Owens, R. M. & Fortey, R. A.** 1982. Arenig rocks of the Carmarthen–Llanarthney district. *In* Bassett, M. G. (ed.), *Geological excursions in Dyfed, south-west Wales*: 249–258. Cardiff, Natl Mus. Wales.

**Paris, F.** 1981. Les chitinozoaires dans le paléozoïque du sud-ouest de l'Europe. *Mém. Soc. géol. miner. Bretagne*, Rennes, **26**. 412 pp., 41 pls.

—— **& Deunff, J.** 1970. Le paléoplancton llanvirnien de la Roche-au-Merle (commune de Vieux-Vy-sur-Couesnon, Ille-et-Vilaine). *Bull. Soc. géol. miner. Bretagne*, Rennes, (C) **2** (1): 25–43.

**Playford, G. & Martin, F.** 1984. Ordovician acritarchs from the Canning Basin, Western Australia. *Alcheringa*, Sydney, **8:** 187–223.

**Rasul, S. M.** 1974. The Lower Palaeozoic acritarchs *Priscogalea* and *Cymatiogalea*. *Palaeontology*, London, **17** (1): 41–63.

—— 1976. New species of the genus *Vulcanisphaera* (Acritarcha) from the Tremadocian of England. *Micropaleontology*, New York, **22** (4): 479–484.

—— 1979. Acritarch zonation of the Tremadoc Series of the Shineton Shales, Wrekin, Shropshire, England. *Palynol.*, Dallas, **3:** 53–72.

**Rauscher, R.** 1968. Chitinozoaires de l'Arenig de la Montagne Noire (France). *Revue Micropaléont.*, Paris, **11** (1): 51–60.

—— 1973. Recherches micropaléontologiques et stratigraphiques dans l'Ordovicien et le Silurien en France. Étude des acritarches, des chitinozoaires et des spores. *Sciences géol. Inst. Géol. Strasbourg*, (Mém.) **38**. 224 pp., 12 pls.

**Staplin, F. L., Jansonius, J. & Pocock, S. A. J.** 1965. Evaluation of some acritarchous hystrichosphere genera. *Neues Jb. Geol. Paläont. Abh.*, Stuttgart, **123** (2): 167–201, pls 18–20.

**Timofeev, B. V.** 1958. Über das Alter sächsischer Grauwacken. Mikropaläophytologische Untersuchungen von Proben aus der Weesensteiner und Lausitzer Grauwacke. *Geologie*, Berlin, **7:** 826–845.

—— 1959. Drevneyshaya flora Pribaltiki i ee stratigraficheskoe znachenie. [The most ancient flora of the Prebaltic and its stratigraphical significance]. *Trudy̆ vses. neft. nauchno-issled. geol.-razv. Inst.*, Leningrad, **129**: 1–319, 25 pls (many of them multiple). [In Russian].

**Turner, R. E.** 1984. Acritarchs from the type area of the Ordovician Caradoc Series, Shropshire, England. *Palaeontographica*, Stuttgart, (B) **190**: 87–157.

—— **& Wadge, A. J.** 1979. Acritarch dating of Arenig volcanism in the Lake District. *Proc. Yorks. geol. Soc.*, Hull, **42** (3): 405–414.

**Vanguestaine, M.** 1978. Critères palynostratigraphiques conduisant à la reconnaissance d'un pli couché Revinien dans le sondage de Grand-Halleux. *Annls Soc. géol. Belgiq.*, Liège, **100**: 249–276.

**Vavrdova, M.** 1965. Ordovician acritarchs from Central Bohemia. *Věst. ústřed. Úst. geol.*, Prague, **40**: 351–357.

—— 1966. Palaeozoic microplankton from Central Bohemia. *Čas. Miner. Geol.*, Prague, **11**: 409–414.

—— 1972. Acritarchs from Klabava Shales (Arenig). *Věst. ústřed. Úst. geol.*, Prague, **47**: 79–86.

—— 1973. New acritarchs from Bohemian Arenig (Ordovician). *Věst. ústřed. Úst. geol.*, Prague, **48**: 285–289.

—— 1976. Excystment mechanism of Early Paleozoic acritarchs. *Čas. Miner. Geol.*, Prague, **21**: 55–63.

**Wicander, E. R.** 1974. Upper Devonian–lower Mississippian acritarchs and prasinophycean algae from Ohio, U.S.A. *Palaeontographica*, Stuttgart, (B) **148**: 9–43.

—— **& Wood, G. D.** 1981. Systematics and biostratigraphy of the organic-walled microphytoplankton from the Middle Devonian (Givetian) Silica Formation, Ohio, U.S.A. *Contr. Ser. Am. Ass. stratigr. Palynologists*, Dallas, **8**. 137 pp., 17 pls.

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